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Massachusetts Agricultural Viability Study

to by

Mark R. Bailey ... *Est. ab. J. --*
Lisa J. Rosenberger
Michael R. Kolman

with

Mary Lee Rhodes
Vivian M. Brady



In Cooperation with the Massachusetts
Department of Food and Agriculture and
the Massachusetts Agricultural Experimental
Station

December 1982

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ABSTRACT

Massachusetts' agriculture has declined substantially in recent decades, both in terms of land and total production. This study identifies the economic factors and processes which have precipitated this decline. The competitive position of the state's agriculture is primarily constrained by unavailability of reasonably priced agricultural land resulting in small farm size and commensurate low farm income; a limited quantity of large continuous blocks of productive land; higher prices for agricultural chemicals, fertilizers, and petroleum products; extensive importation of feed grains and commensurate higher total costs; significantly higher taxes on agricultural land and buildings; and a multitude of nonagricultural demands for farmland. Future viability of various agricultural sectors favor those that use the land resource more intensively (fruit and vegetable farms) relative to those that use land extensively (dairy and other livestock operations). The Commonwealth of Massachusetts has adopted agricultural assessment of farmland to decrease tax liabilities, has implemented the Agricultural Preservation Restriction Act whereby the development rights to agricultural land are purchased, and has developed an active "buy Massachusetts grown products" campaign. Other policy alternatives that may be considered by the Commonwealth of Massachusetts in future program initiatives aimed at assisting the agricultural sector, are presented.

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PREFACE

The Economic Research Service (ERS), U.S. Department of Agriculture (USDA), in cooperation with the Soil Conservation Service (USDA), the Massachusetts Agricultural Experiment Station and the Massachusetts Department of Food and Agriculture developed and conducted the Massachusetts Agricultural Viability Study (MAVS). The Study was conducted under authority granted to the USDA in Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 83-566, as amended).

The MAVS was initiated in October 1978 primarily in response to a request by Frederic Winthrop, Commissioner, Massachusetts Department of Food and Agriculture. Commissioner Winthrop expressed his Department's position as follows:*

While this department has attempted to spearhead the drive to halt the decline of agriculture in Massachusetts, we have done so with a paucity of data on which to formulate our plans. We have nonetheless set policies at the state level and have successfully influenced the legislative process in favor of local agriculture, but we have done so without clear assurance as to the soundness of our approach and without the ability to always justify our programs in economic terms.

As an example, this is particularly true in the land use area where the successful implementation of the recently enacted Agricultural Preservation Restriction Act (Chapter 780) will depend on our ability to make informed decisions as to which land should be saved for agricultural production. Future marketability of selected commodities, farm size and location, soil types, multiplier effects, impacts of government actions, effects on water supply, benefits to the locality and the region, and many other considerations must be made.

A number of other concerns in addition to those identified by Commissioner Winthrop were considered in developing this study:

1. What is the social value of agriculture;
2. What are impacts of the Agricultural Preservation Restriction Act upon agricultural viability;
3. What are the erosion rates and impacts upon water quality and farm income;
4. What is the competitive position of Massachusetts agriculture;
5. What is the critical mass of agriculture in Massachusetts, and does it act as a constraint to farming;
6. What are some possible policy alternatives that would assist the State in maintaining or enhancing the agricultural sector.

* Commissioner Winthrop's letter to Dr. Benjamin Isgur, former State Conservationist, Soil Conservation Service, U.S. Department of Agriculture, June 20, 1978.

A set of objectives derived from the stated concerns were developed to guide the study:

1. Examine the declining trend of agriculture and identify and analyze the causes of that decline;
2. Compare trends in Massachusetts agriculture with those other States that export food crops to Massachusetts, in order to assess the competitive position of the State's agricultural sector;
3. Assess present erosion rates in Massachusetts and analyze the impacts of alternative conservation practices;
4. Estimate the social value of agriculture;
5. Analyze the critical mass components of Massachusetts agriculture to determine the present and potential limitations that it may place on the agricultural sector;
6. Analyze the Agricultural Preservation Restriction program as to its present and potential impacts on the agricultural sector;
7. Discuss possible policy alternatives that the State may wish to consider in instituting policies to maintain or enhance the agricultural sector;
8. Suggest areas of pertinent future research.

The primary approach of the study was to stratify the agricultural sector into its major enterprise groups - fruit, vegetable, other field crop, dairy, poultry, and other livestock farms. Each enterprise group in Massachusetts was analyzed and compared with its counterpart at the national level and in other States in order to estimate the competitive position of Massachusetts agriculture. A series of production input and output indices were developed in order to identify those components which affect the economic viability of Massachusetts agriculture.

The MAVS culminates in a discussion of the endogenous and exogenous factors that have had an impact on the agricultural sector. A discussion of possible policy and program alternatives is presented that may be of use to the Massachusetts Department of Food and Agriculture in their program development.

ACKNOWLEDGEMENTS

The support and assistance of many agencies and people were invaluable in the design and conduct of this study. Philip Christensen, formerly the Assistant State Conservationist of the Massachusetts office of the Soil Conservation Service (SCS), USDA, and presently the SCS State Conservationist in Connecticut, provided the initial impetus and support for the study. John Hostetler, the former Northeast Program Leader, Natural Resource Economics Division (NRED), Economic Research Service (ERS), USDA, provided much guidance in the design and methodology used in this study. Anthony Grano, the present Head of the Northeast Section, NRED, ERS, provided many methodology refinements and a great deal of relevant advice that significantly improved the quality of the study.

Robert Christensen and John Foster, Department of Food and Resource Economics, University of Massachusetts, provided data, advice and constructive reviews of the material set forth in the report.

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MASSACHUSETTS AGRICULTURAL VIABILITY STUDY

by

Mark R. Bailey*

Lisa J. Rosenberger

Michael R. Kolman

with

Mary Lee Rhodes

Vivian M. Brady

CHAPTER I

INTRODUCTION

STATEMENT OF PROBLEMS

Experts disagree about whether the continuing conversion of agricultural land to non-farm uses will ultimately impair the ability of the U.S. to provide sufficient food and fiber for both home consumption and export. Even if the loss of farmland is not an issue of national importance, farming and farmland provide both economic and amenity benefits to the residents of Massachusetts, and thus agricultural retention is an issue of public concern. The total amount of land in farms in Massachusetts declined by nearly sixty percent between 1950 and 1978, from 1.7 million acres to about 680,000 acres. Land in farms (which includes farm woodlots) now constitutes only about 13 percent of the total land area of the State. Urban development claimed nearly 9,000 acres per year of cropland and pastureland between 1967 and 1977, and prime farmland has been converted to urban uses at a faster rate than nonprime land. Idling of active farmland has also been widespread.

The myriad of factors and processes which have led to the decline of agriculture in Massachusetts can be traced to several exogenous forces, which originate outside the State's farming sector and are, for the most part, beyond the control of the State and local governments. These exogenous forces include: urban expansion, technological change in agriculture, the implementation of Federal programs (especially in regard to transportation), and shifts in consumer and export demand. In many cases, the net effect of these trends has

*Bailey is an agricultural economist with the Natural Resource Economics Division, Economic Research Service, USDA. Rosenberger, formerly an Economic Assistant employed through a cooperative research agreement with the University of Pennsylvania is now the Staff Economist, New Jersey Pine Barrens Commission. Kolman is an Agricultural Economist, in the Massachusetts State office of USDA's Soil Conservation Service. Rhodes and Brady were former Economic Assistants with NRED.

been to reduce the competitive position of Massachusetts' farmers relative to those in other regions, in part because the ability of the State's agricultural industry to adapt to change is constrained by high price of agricultural land, climate, topography, distribution of prime soils, size of farms, and other structural factors. While it is difficult to control the exogenous forces themselves the direct and indirect local effects of external change can be modified to enhance the economic viability of farming and preserve valuable farmland. Listed below are some of the major catalysts to agricultural decline in Massachusetts identified in this report:

- The average market value of farm real estate per acre in Massachusetts is over two times the average value nationwide, and over 130 percent higher than the average for the Northeast. High land prices result in higher taxes and increase the opportunity cost of farming and hinder expansion and entry into agriculture.

- Property taxes are nearly six times higher in Massachusetts than in the U.S. as a whole, on a per acre basis. Farmers in Massachusetts spend about 6.2 percent of their gross income on property taxes, compared to 3.2 percent nationwide.

- Massachusetts farmers pay higher prices for most fertilizers, pesticides, and petroleum products than those within and outside the New England Region.

- Dairy and livestock farms spend, as a proportion of total revenues, about 25 percent more on livestock feed in Massachusetts than in the U.S. as a whole. Ninety-seven percent of dairy rations are purchased from commercial mixers.

- Expenditures for hired labor represent a higher proportion of gross income in Massachusetts than in the nation for all farm enterprise groups.

- The incompatibility of urban and agricultural land uses has accounted for perhaps as much as fifty percent of the idling of farmland in eastern Massachusetts.

Views of the Agricultural Land Resource

Agricultural land is one of the most indispensable of man's resources. The current and future status of this resource has been the subject of a considerable amount of economic and conservationist literature (some that dates back to the British classical economists) that incorporates many differing views on the scarcity of arable land. Analysts have generally concurred about two basic characteristics of the land resource: that a purely physical limit to the total world supply of agricultural land exists; and that farmland is essentially a renewable resource in that it can be typically used over and over again, perhaps indefinitely if properly managed. Apart from these gross characterizations, however, there is little consensus concerning such issues as: the proper definition

and measurement of the resource; the degree to which other agricultural inputs can be substituted for land and for how long; and whether or not the earth's supply of agricultural land is adequate to sustain a growing world population.

Thomas Malthus was perhaps the first to develop a comprehensive theory of the scarcity of agricultural land. In his famous Essay on the Principle of Population (22) 1/, he postulated that population tends to grow exponentially, while the supply of agricultural land is essentially finite and food production can expand only at an arithmetic rate at maximum. As a result, population puts continually increasing pressures on farmland, making it progressively more scarce. When food demand begins to exceed supply, population is reduced either through "positive checks" (such as famine, war, and disease) that serve to increase mortality, or through "preventive checks" that result in decreased birth rates. In Malthus' view, the necessary imposition of such checks is detrimental to human welfare, and therefore the scarcity of agricultural land relative to population poses a grave problem for mankind.

The classical economist David Ricardo put forth another hypothesis concerning the scarcity of agricultural land which stresses not so much the finiteness, or absolute scarcity of the resource, as its variation in quality over space (2). He assumes that the most productive land must be brought into production. In Ricardo's view, while famine may be averted, agriculture will be characterized by decreasing productivity, and an increasing proportion of personal income will be spent upon the consumption of food.

Resource economists in this century have rather drastically altered the classical views of resource scarcity, stressing the "derived demand" for resources and the substitutability of inputs. Zimmermann (1951) stated emphatically that "the word 'resource' does not refer to a thing or substance but to a function which a thing or substance may pertain or to an operation in which it may take part..." (63, p. 7). In other words, the resource has no value except insofar as it is used to satisfy a human need or want, and it may not be uniquely capable of performing a given function. This definition of resources led to the formulation of the notion of "substitutability" by Barnett and Morse (1963), whereby technological advances in agriculture permits the substitution of other productive inputs (fertilizer, improved seed stocks, drought and disease resisting plants, etc.) for land. As a consequence, resource scarcity can be forestalled and productivity may, in fact, be enhanced over time (2).

Agriculture in the United States

The historical evidence appears to support the substitutability thesis, at least in the United States. It can be shown that the price of agricultural goods has not risen in relation to other commodities (34), and agricultural productivity, as measured by the U.S. Department of Agriculture, has risen by 140 percent since 1910 (49). Nevertheless, in the 1970's a renewed interest in the agricultural land resource emerged, and resulted in the National Agricultural Lands Study (26).

1/ Underscored numbers in parenthesis refer to literature cited at the end of this report.

In addition to the loss of farmland acreage, about 25 percent of all cropland in the U.S. is being eroded at a rate of more than five tons of soil per acre per year (10, 28). The continued loss of topsoil in excess of this rate, depending upon location and productive soil depth, could significantly reduce the productive capability of land in the future. Another potential threat to future production is the "mining" ^{2/} of groundwater aquifers, particularly in the southwestern and southern Plains area of the U.S., largely due to irrigation (10). If the aquifers are sufficiently depleted, land currently used for crops may have to be removed from intensive use.

These trends in urban and related development, soil erosion, and mining of aquifers serve to reduce the finite productive land resource. In addition, a slowing of the growth in agricultural productivity gains in recent years, coupled with a large increase in export demand, has dramatically altered the balance of supply and demand for U.S. farm products in the last decade. The large surpluses in production, typical of the decades between 1950 and 1970, no longer exist for many commodities. This combination of trends, plus the possibility that in the future new demands may be placed on the land, (e.g., providing biomass for energy) has caused some analysts to speculate that continued depletion of the agricultural land resource may have serious long-term consequences (10). Even if U.S. farmers are always able to supply enough food and fiber for their own countrymen, a continued surplus of production for export is needed for economic and strategic, as well as humanitarian reasons. Many resource and agricultural economists, however, believe that no real or potential economic scarcity of farmland exists in the U.S. (16, 37), and the Census of Agriculture shows that harvested cropland has increased rather than decreased nationally in the last decade. Thus, the issue of whether steps should be taken in the public interest to preserve agricultural land has not been fully resolved at the national level.

The Social Value of Agriculture

Regardless of whether the loss of farmland is a national or a world problem, agricultural land and the farming industry may hold considerable value for the residents of individual regions, and this value may encompass both economic and non-economic benefits. For example, farming provides jobs or supplemental income not only to farmers, but to those who depend on the farming sector. The first-order backward and forward linkages to agriculture include farm supply and equipment dealers, feed mills, food processing industries, food distributors, etc. An increase in the output of any or all of these sectors would have multiplier effects on the rest of a region's economy.

Apart from the direct and indirect employment opportunities offered by farming, there is also a concern, especially pronounced in the Northeast and Massachusetts, with the issue of becoming more self-sufficient in agriculture (1, 24). This concern has arisen, in part, because food costs are an estimated six to ten percent higher in Massachusetts than in the U.S. as a whole, due to the higher

^{2/} "Mining" of an aquifer occurs when the rate of groundwater withdrawal exceeds the rate of recharge from precipitation and surface waters.

costs of transporting goods to the New England market. In addition, reduced dependency on external food sources means less vulnerability to forces beyond the control of the State, such as strikes by rail or trucking employees, western droughts, or other interruptions in the transport or production of agricultural commodities. It is estimated that Massachusetts currently supplies only about 2 percent of the meat products, 20 percent of the dairy products, 16 percent of the poultry and eggs, and 18 percent of the fruits and vegetables, consumed in the State. Overall food self-sufficiency is estimated at about 7 percent. The maximum level of self-sufficiency which could be attained in Massachusetts (if all potential cropland were planted to fruits and vegetables), is about 24 percent for the four categories combined (7). Thus, while the State cannot become totally independent of imported food sources, the situation could be improved.

Finally, environmental and aesthetic values have often played a role in stimulating public support for agricultural preservation programs. Two different methods for measuring the amenity value of agricultural land as open space were analyzed as part of this study. Three towns in Massachusetts were examined: Greenfield and Deerfield in Franklin County, and East Longmeadow in Hampden County. ^{3/} Greenfield and Deerfield are primarily rural in character, except for the urban center of Greenfield (population 19,000), while East Longmeadow, which is part of the Springfield Metropolitan area, is considerably more urbanized.

The first method employed the hedonic, or property value technique. This method involves measuring residential property values (selling prices) as a function of distance from agricultural land, controlling for other variables which describe age, size, and condition of each house and lot. In the analysis of the three towns, the distance to agricultural land variable is statistically significant only for the Deerfield sample. In Deerfield, a house adjacent to farmland sells for about \$2,600 more than one located 338 or more feet away. This differential can be termed the "agricultural amenity," or the additional amount households are willing to pay for houses adjacent to farms. The amenity value, however, drops to zero at distances of more than 337 feet; therefore, the number of households which receive benefits is relatively small.

A fuller measure of social value can be achieved with the willingness to pay method, which is a survey technique designed to determine how much households would pay to prevent the development of nearby farms. Eighty-five households were surveyed in the three towns, and based on the responses elicited, the social value of farmland in Deerfield is estimated to be about \$43 per acre, \$143 per acre in Greenfield and, in the more urban town of East Longmeadow, \$337 per acre. These figures are obtained by multiplying the mean bid (the average amount each household surveyed is willing to pay to prevent the development of nearby farmland) by the number of households in each town, divided by the acres of farmland in each town. Willingness to pay is lower if the land is to be only partially developed. While additional research is needed to determine the social value of other agricultural land in Massachusetts, it is clear that nonfarm residents do consider farms to have amenity value.

^{3/} Halstead, John Michael. "Social Value of Agriculture Land Using Hedonic and Iterative Bidding Techniques: A Comparative Approach," unpublished M.S. thesis, September 1981. This study was supported by USDA through a Cooperative Research Agreement with the Massachusetts Agricultural Experiment Station, Amherst, MA.

The Loss of Farmland in Massachusetts

Massachusetts has experienced a long-term and precipitous decline in agriculture, and has implemented Statewide programs designed to slow this decline. Between 1880 and 1978, land in farms in Massachusetts fell from 3.4 million acres to 680,000 acres, an 80 percent decrease (54). The National Agricultural Lands Study (NALS) estimates that 30,000 acres per year of active and potential agricultural land were converted to urban and related uses 4/ in Massachusetts between 1967 and 1977. About one-third of this land was cropland or pastureland prior to conversion while the remainder was forested. Nearly 10,000 acres per year of prime agricultural soils were built upon during this decade (27). Losses of pastureland have occurred at the fastest rate (a 28 percent decrease from 1967 to 1977), followed by cropland (14 percent), while forestland declined by 10 percent during the decade. Farmland is relatively more vulnerable to development than forestland, since it is already cleared, is generally located near transportation networks, and often has well-drained soils and gentle topography.

The National Agricultural Lands Study defines "agricultural land" as all land which is either currently farmed or has the potential to be farmed. Therefore the NALS data show changes in the total available land resource. However, the use of this resource, or what remains of it, has also shifted in recent decades.

Foster and MacConnell (14) estimate that between 1951 and 1971, a total of 13,300 acres per year were lost from agricultural use in Massachusetts, of which 6,900 acres were pasture, 5,900 acres were tilled, and 500 acres of orchards. Urbanization claimed the single largest portion of this land (5,300 acres per year), but substantial acreages were classified as abandoned 5/ (unused farmland, 4,200 acres per year), or were abandoned and had already reverted to forest (2,700 acres per year). In fact, the total amount of land which was simply idled during this period exceeded that which was converted to urban and related uses. However, more cropland was converted to urban uses than was abandoned. While abandoned farmland may eventually be reclaimed if necessary, the loss of current productive capacity is also a matter of concern to many State and local officials.

4/ Includes land used for residences, industrial sites, commercial sites, construction sites, railroad yards, small urban parks, cemeteries, airports, golf courses, shooting ranges, transportation facilities, and areas flooded by dams.

5/ "Abandoned" farmland is land which was once actively farmed, but which is no longer used for agricultural purposes or any other active use. If this land remains idle most of it will eventually revert to forest.

CHAPTER II

CHARACTERISTICS OF MASSACHUSETTS AGRICULTURE

CHAPTER SUMMARY

Cropland and pastureland constitute a rather small proportion of the total land area of Massachusetts (7.4 percent) while forest and urban uses predominate. About 450,000 acres (9 percent) of the State's land is considered prime farmland (i.e., highly suited to agricultural production), yet only about one-third of this land is currently used for crops. Compared to the U.S. and the Northeast as a whole, Massachusetts agriculture is characterized by small farm size, high farm real estate values, and a high proportion of owner-operated farms. The major agricultural commodities produced in the State are dairy products, greenhouse and nursery products, cranberries, hay, eggs, apples, and vegetables. Since 1959, however, there continues to be a shift to those enterprise groups which use land more intensively (e.g., fruits, vegetables, etc.) because of higher values of output per acre of land used.

The Use of Land in the State

Massachusetts is one of the more urbanized States in the nation. In 1977, twenty-five percent of the State's land was classified as urban or built-up, while for the Northeast and the U.S., the proportions of urban land were only 11.3 percent and 4.5 percent, respectively (26). Average population density in Massachusetts was 739 persons per square mile in 1970 compared with 302 for the Northeast and 61 for the U.S. The largest single land use in Massachusetts, however, is forest, which accounts for over half the land base (Table 1).

Table 1--Land Uses in Massachusetts, 1977

Land Use Category	Acres Thousand	Percentage of Total Percent
Cropland	282	5.6
Pastureland	91	1.8
Forestland	2,756	54.6
Other Land in Farms	38	0.8
Farmsteads	24	0.5
Rural Transportation	106	2.1
Rural Nonfarm	385	7.6
Water	51	1.0
Urban	1,243	24.6
Federal land	75	1.5
TOTAL	5,051	100.0
Prime Farmland (1)	448	8.9

(1) "Prime farmland" is defined as cropland, pastureland, or forestland which is highly suitable for agricultural production, due to physical factors such as gentle topography, resistance to soil erosion, and high soil fertility. Precise criteria and inventory procedures are given in the Federal Register, Vol. 43, No. 21, January 31, 1978.

Massachusetts has 448,000 acres of prime soils of which 161,000 acres are currently in cropland use. The National Agricultural Lands Study estimates that of the land remaining which is not now being farmed, 33,000 acres have a high potential for conversion to cropland, and another 144,000 acres have medium potential. Another study estimated the total agricultural land resource base in 1971 to be 1,092,788 acres (21.7 percent of the State's land area), of which 438,644 acres were actively farmed (6). Therefore, although the agricultural land resource in Massachusetts is relatively small, much is, nevertheless, not currently used for farming purposes.

Land in Farms and the Farm Population

Farms and farmers in Massachusetts exhibit some rather unique characteristics when compared to the U.S. or even the Northeast. In general, agriculture in Massachusetts is characterized by:

- . a small amount of farmland relative to total land area
- . under-utilization of prime land for cropland
- . high land values and high farmland taxes
- . small farm size (acres)
- . low rate of farmland leasing

As could be expected, the State exhibits greater differences from the nation as a whole than from the Northeast (Table 2).

The small farm size and high land values are probably two of the most important factors which explain the decline of farming and its relatively minor importance to the Massachusetts economy. Small farms cannot take advantage of the economies of scale which have accompanied technological advancement and the increased use of capital in agriculture nationwide. High land prices make it difficult for new farmers to become established, while encouraging existing farmers to sell land to speculators and developers.

In most respects, farm operators in Massachusetts do not significantly differ from their counterparts elsewhere. Slightly more than half report farming as their principal occupation, while 48 percent work 100 days or more off the farm, compared to 44 percent nationwide. More farmers in Massachusetts are full owners of their farms (65%) than in the Northeast (62%) and the U.S. as a whole (58%). The average age of farm operators (51.9 years) in Massachusetts is less than two years higher than the national average.

Types of Farm Products

The agricultural sector is, of course, not homogeneous; many different types of crops and livestock are grown. Due to variations in climate, topography, soils, distance to input sources and markets, and other locational factors, each region of the U.S. tends to specialize in the production of certain agricultural commodities. In Massachusetts, while dairy operations still dominate

the agricultural sector, fruit and vegetable operations are becoming more significant. High land values in the State are forcing a shift to those enterprise groups that employ land more intensively.

However, farmers in Massachusetts could be expected to have a competitive advantage in certain agricultural enterprises, due to their proximity to a large consumer market. Specifically, highly perishable commodities and those which are sold directly for consumption with little or no intermediate processing can be profitably produced in Massachusetts. In addition, the intensity with which land is cultivated tends to increase near the market due to increasing land values. One measure of the intensity of cultivation is the value of output per unit of land. In the U.S., nursery/greenhouse products and poultry farming yield the highest output per acre ^{6/}, followed by vegetables and fruits and nuts. Livestock, dairy, and field crop farming use land less intensively. Many farmers in Massachusetts, who are close to markets and whose land has a high value, are shifting their efforts to such enterprises as nursery/greenhouse operations, vegetables, and fruit.

In terms of the actual distribution of agricultural output (measured by value of sales), Massachusetts has only a slightly higher concentration in crops versus livestock than the U.S., but within these broad categories the differences are substantial (Table 3). Dairy products constitute the largest single commodity produced in the State, accounting for 28.7 percent of all farm sales (compared to 10.4 percent for the nation). While dairy farms have a relatively low ratio of output to land, milk is a highly perishable good and is therefore often produced relatively near to markets. Nursery/greenhouse products also constitute a large percentage of agricultural output in Massachusetts, which is not surprising in light of the low land requirements and market orientation of this industry. After dairy and nursery/greenhouse, the next three largest sectors in terms of value of sales are fruits, poultry products and vegetables, all of which represent relatively intensive uses of land. ^{6/} In contrast, the largest agricultural sectors nationwide are field crops and cattle and calves. These industries tend to exhibit substantial economies of scale and have high land requirements, and hence are not suited to Massachusetts.

Hay and corn for silage account for the largest field crop acreages in Massachusetts (Table 4) although the volume of sales of these products is low because most of the output is consumed by livestock on the farms where it is grown. Cranberries are an important fruit crop in Massachusetts. Apples, peaches, tobacco, potatoes, sweet corn, and a variety of vegetables are also grown in the State. Some income is derived from the associated sale of cattle and calves (mostly cull dairy cows and calves), and chickens (primarily spent layers). Some farmers in the State raise turkeys, and sheep and lambs, and hogs.

^{6/} Poultry farms use very little land because feed is generally imported rather than produced on the farm. When the acreage of feed grain required to support chickens is taken into consideration, output per unit of land is much lower.

Table 3--Percent Distribution of Value of Agricultural Products Sold in 1978,
Massachusetts and the United States (1)

	Massachusetts	United States
	- percent -	
Total Crops	47.0	45.1
Field Crops	3.9	30.0
Tobacco	3.3	2.2
Cotton	0	2.9
Vegetables	6.4	3.0
Fruits	14.2	4.3
Nursery/Greenhouse Prod.	19.2	2.7
Total Livestock	53.0	54.8
Poultry & Poultry Products	8.7	7.9
Dairy Products	28.7	10.4
Cattle and Calves	5.9	27.6
Sheep, lambs, and wool	0.1	0.6
Hogs and Pigs	2.6	7.5
Other Livestock	7.0	0.8

N/A - not available

Note -- may not add to 100 because of rounding.

(1) Computed from data that excludes those farms selling less than \$2500 to make 1978 data more comparable to previous censuses (see footnote 8, pg. 24).

Source: Census of Agriculture, 1978

Table 4--Agricultural Production and Value of Sales in Massachusetts, 1978

Major Crops	Unit	Value of Sales
	<u>Acres</u>	<u>Thousand dollars</u>
Corn for silage	40,000	0
All hay	116,000	19,126
Tobacco, shade type	860	8,385
Tobacco, havana seed	160	326
Potatoes	3,600	5,103
Sweet Corn	6,500	4,004
Tomatoes	670	3,074
Cranberries	11,200	25,488
Apples	N/A	12,726
Peaches	N/A	1,015
Maple Syrup	N/A	426
<u>Livestock</u>	<u>Inventory</u>	
Cattle and calves	99,000	11,734
Hogs	60,000	7,792
Sheep and lambs	6,800	226
Chickens	1,580,000	1,298
Turkeys	146,000	2,035
<u>Livestock Products</u>	<u>Production (lbs.)</u>	
Milk	572,000,000	68,526
Wool	43,000	32
Eggs	28,416,700(1)	18,812
Honey	420,000	433

(1) Egg production expressed in dozens.

Source: Massachusetts Agricultural Statistics, 1979

N/A = not available.

Agricultural Water Quality Impacts

Section 208 of the Federal Water Pollution Control Act of 1972 required the preparation of non-point source water quality management plans. Most of these plans were prepared on a regional basis. Non-point water pollution resulting from agricultural activities was generally not addressed adequately by these plans, although sediment resulting from soil erosion is widely recognized as a major contributor to water quality problems. In recent years, the amount of land devoted to the production of corn for silage has increased, while hay production has declined somewhat (29). If these trends continue, there is potential for serious erosion problems in the future.

As part of this study, an erosion evaluation model was developed as a means to assess the potential impact upon farm income if erosion levels on agricultural land were to be decreased to acceptable levels. A model of this type can be made site specific to assess particular areas; moreover, various soil conservation and agricultural production policies can be evaluated. Appendix I contains a description of the model and the findings. The Soil Conservation Service is currently preparing a more thorough analysis of agriculturally induced water quality impacts as part of the Massachusetts Agricultural Water Quality Study.

CHAPTER III

THE HISTORY OF MASSACHUSETTS AGRICULTURE, 1850-1974

CHAPTER SUMMARY

Historical trends in Massachusetts agriculture partly reflect national and regional trends, although the changes have often been more pronounced in Massachusetts. Number of farms, farm population, and land in farms have declined sharply in the state since 1940, accompanied by a steep rise in the average value of an acre of farmland. The average size of farms in Massachusetts has also increased in recent decades, although not nearly as rapidly as in the U.S. Many of these trends are associated with the nationwide shift of agriculture from a labor-intensive to a capital-intensive industry. Due to the constraints of farm size, climate, and topography, combined with high land prices induced by widespread urbanization, Massachusetts agriculture has not adapted as well to many technological changes as has farming in other States. Also, the interstate highway system has given farmers in other regions increased access to Northeastern markets. Thus, in many cases, the competitive advantage of Massachusetts farmers relative to producers in other parts of the country has been reduced.

Overview

In the last section, the salient features of Massachusetts agriculture in the late 1970's were outlined. In order to better understand the forces which have led to current conditions, it is helpful to trace past trends in relation to those of the Northeast and the United States. It will be seen that while overall trends in the State often reflect those of the United States and particularly the Northeast, the changes have typically been more pronounced in Massachusetts. In many ways, the State can be viewed as an extreme example of the historical tendencies which have characterized the Northeast generally.

Major Structural Changes, 1850-1974

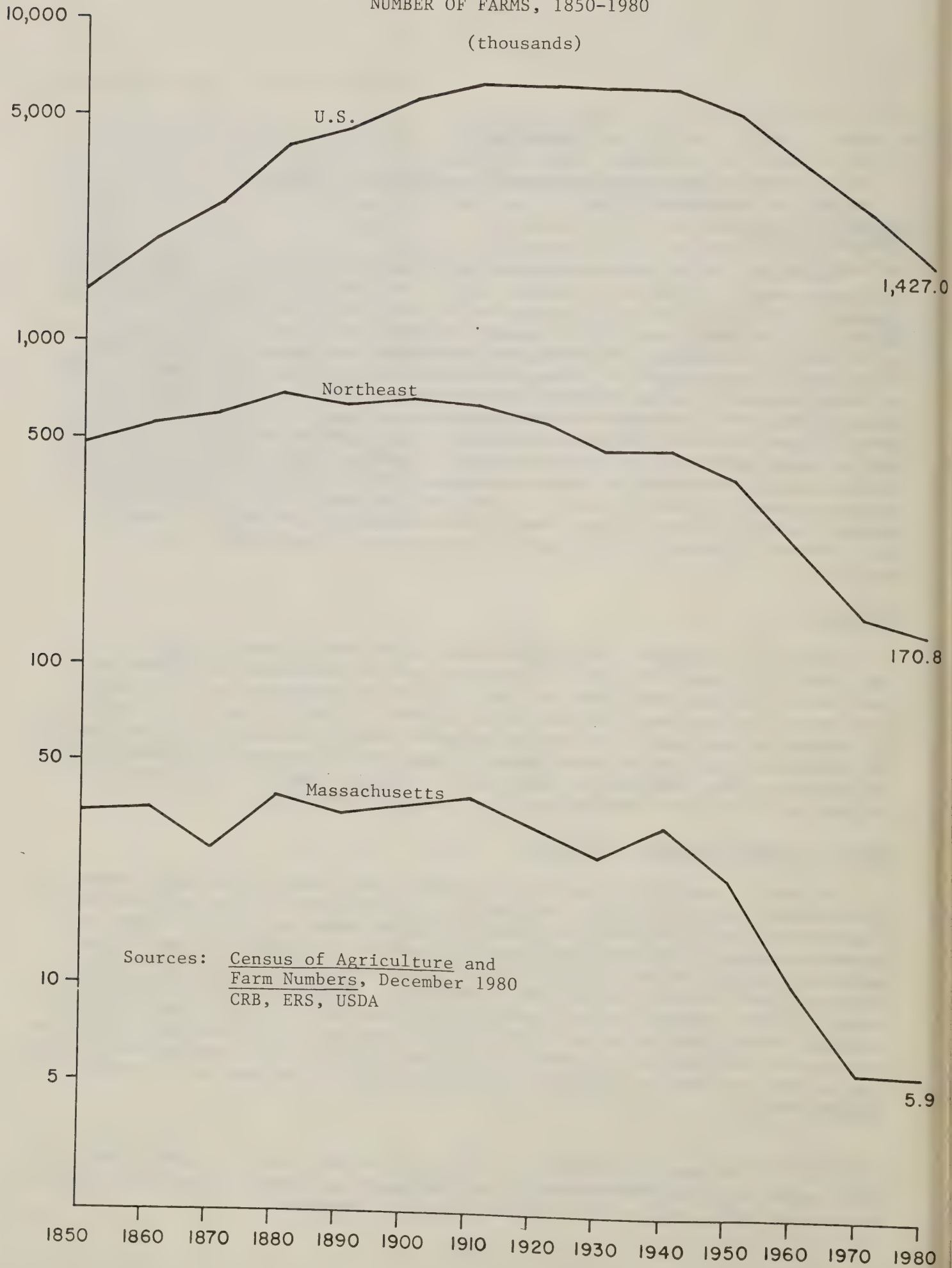
Figures 1 through 5 summarize, in graphic form, some of the major trends in agriculture from 1850 to 1974 for the U.S., the Northeast and Massachusetts. ^{7/} From 1850 to 1940, the number of farms in the Northeast and Massachusetts remained essentially the same (with some fluctuations in Massachusetts), while numbers increased in the U.S. until 1900, as the West continued to be settled, and stabilized between 1900 and 1940 (Figure 1). Then suddenly after 1940, the number of farms dropped rather dramatically throughout the U.S., including Massachusetts, which experienced an eighty percent decline. Farm population exhibited a concurrent and similar decrease, going from 23.2 percent of the national population in 1940 to only 3.0 percent in 1978, and from 3.4 percent to 0.5 percent in Massachusetts.

^{7/} Most of the graphs presented in this section are plotted on semi-logarithmic graph paper, so that Massachusetts, the Northeast, and the U.S. can all be plotted in the same units, and so that the curves appear smoother.

Figure 1

NUMBER OF FARMS, 1850-1980

(thousands)



The causes of this nationwide trend toward fewer farms and farmers have been well documented (35, 43, 52). Basically, the shift can be attributed to technological innovation in agriculture, which led to a rapid substitution of capital for labor (Table 5). In 1910, labor accounted for over 50 percent of all farm inputs, while by 1950 it represented only 38 percent, and by 1976 labor supplied only 16 percent of total inputs. Conversely, machinery's share of inputs increased from 8.5 percent in 1910 to 31.3 percent in 1976, and the use of agricultural chemicals (fertilizers and pesticides) also grew substantially, from 1.7 percent of the total inputs in 1910 to 9.6 percent in 1976. At the same time, nonfarm employment opportunities became far more numerous as the general economy grew after World War II, and manufacturing wages were typically higher than farm incomes, resulting in the migration of workers from the farms to the cities.

The substitution of capital for labor, which was responsible for a large increase in total productivity, made economies of scale much more pronounced for many farm enterprises. The purchase of large and expensive equipment was feasible only on relatively large farms, and it was therefore these farms which were able to achieve diminishing marginal costs and a decline in long run average costs. As a result, small farmers became less competitive, and farms were consolidated into larger and larger units.

However, recently the pattern of farm numbers has significantly changed. While 8,000 new farms came into existence in the U.S. between 1974 and 1978, most of these are small farms that do not generate enough income to support a farm family, thus the operator also earns off-farm income. At the same time, the trend of increasing numbers of large farms continued, with mid-size farms fading in numbers (50). Mid-size family farms are losing ground which may be due to the increase in small farms and the fact that relatively small numbers of larger farms are continuing to capture an increasing share of commercial farm production. Thus, if these trends continue, U.S. agriculture may be characterized by only two classes of farms - large farms producing more and more of agricultural goods and small farms that serve primarily as rural residences (50).

While farms in Massachusetts and the Northeast have always been smaller than those in other parts of the country, the gap has widened considerably in recent decades (Figure 2). Several factors account for this phenomenon: (1) the Northeast and particularly Massachusetts are characterized by ownership of land in small parcels, reflecting a land tenure pattern dating back to colonial times, (2) areas of fertile soils are relatively few and scattered; hence, it is often difficult to assemble contiguous tracts of prime land into a single farm unit, (3) hilly topography hampers the use of some types of large machinery, and (4) high land prices make the purchase of large tracts of land prohibitively expensive for many farmers. For these and other reasons, the trend in farm size in Massachusetts, as well as the Northeast as a whole, has not kept pace with the national trend.

The inability of Massachusetts farmers to take full advantage of the economies of scale which accompanied the increased use of capital in farming may account, at least in part, for the general decline in land in farms and harvested

Table 5--Percentage Distribution of Farm Inputs in the United States

	:	:	:			
	:	1910	:	1950	:	1976
	:	<u>Percent</u>			:	
	:				:	
Labor	:	53.4		38.1		16.0
Land	:	20.2		16.7		21.6
Machinery	:	8.5		20.3		31.3
Agricultural Chemicals	:	1.7		4.7		9.6
Feed, Seed and Livestock Purchases	:	3.2		9.4		7.4
Taxes and Interest	:	8.3		7.5		10.5
Miscellaneous	:	4.7		3.3		3.6
TOTAL	:	100.0		100.0		100.0
	:					

Note: Data

Source: USDA, Economics, Statistics and Cooperatives Service, Measurement of U.S. Agricultural Productivity, February 1980



United States
Department of
Agriculture

Soil
Conservation
Service

P.O. Box 2890
Washington, D.C.
20013

Subject: BASIN AREA PLNG - Massachusetts Agricultural
Viability Study

Date: MAR 30 1983

To: Selection Section
Science and Education
National Agricultural Library

Enclosed for your information is a copy of the recently completed
"Massachusetts Agricultural Viability Study." This report was prepared
under the authority of Section 6 of the Watershed Protection and Flood
Prevention Act, Public Law 83-566.

The U.S. Department of Agriculture carried out this study in cooperation
with the Massachusetts Department of Food and Agriculture and the
Massachusetts Agricultural Experimental Station.

This report is being furnished in accordance with your request to the
Basin and Area Planning Division, Soil Conservation Service. If you need
additional copies or any information pertaining to this report, please
let us know.

EDGAR H. NELSON
Director, Basin and
Area Planning Division

Enclosure



The Soil Conservation Service
is an agency of the
Department of Agriculture

WO-AS-2
10-79

Figure 2

AVERAGE SIZE OF FARMS, 1850-1980
(acres)



Source: Census of Agriculture
and Farm Numbers, ERS, USDA, December 1980

cropland (Figures 3 and 4). Nationwide, the percentage share of farm real estate as an input has remained relatively stable at about 20 percent since 1910 (Table 5). Increasing output has been achieved primarily through the substitution of improved seed stocks, fertilizers and pesticides for land. Therefore, national farm acreage has changed little in recent decades, although there has been a slight decline since 1950. On the other hand, the Northeast and Massachusetts have experienced large reductions in agricultural land, particularly since 1950. In 1850, land in farms constituted 66.7 percent of the total land base in Massachusetts and 53.2 percent in the Northeast; in 1978 the proportions of agricultural land had dropped to 13.0 percent and 25.0 percent, respectively. Harvested cropland has increased somewhat since 1974, but much of the increase is ascribed to the change in the definition of farms used in the 1978 Census of Agriculture.

Another major cause of the decline in farmland in Massachusetts and the Northeast has been the relatively large growth in the number of households, resulting in the conversion of significant amounts of land to urban uses. The competition for farmland from other uses is reflected in the high value of farm real estate which has prevailed in the Northeast and especially in Massachusetts (Figure 5). High land values and associated taxes result in barriers to entry into agriculture by new farmers and for existing farmers to expand their operations. Agricultural decline in Massachusetts has also resulted in part from certain federal programs which have increased the competitive advantage of other regions relative to the Northeast. Specifically, transportation improvements, especially the interstate highway system, have given farmers in other regions much greater accessibility to the large consumer markets in the Northeast. In addition, water projects have opened up massive amounts of western land to intensive production through the provision of low cost water for irrigation (10), although this may change as water availability decreases and costs of pumping for water increase.

Trends in the Production of Specific Commodities

Structural changes in agriculture have affected trends in the production of specific commodities in Massachusetts in varying ways. Data published by the New England Crop and Livestock Reporting Service (29) for the period 1920 to 1978 show that, of major crops grown in Massachusetts, only corn for silage has increased in acres harvested since 1950, due to the increasing substitution of corn silage for hay and grain. Hay and potatoes have exhibited steady declines in acreage since 1940, and acres harvested of most vegetables, including sweet corn and tomatoes, have also fallen in recent years. The cranberry industry, however, remains strong, showing almost continually increasing outputs since 1920. Apple growers have been able to maintain a fairly consistent level of output since 1940. Peach production, on the other hand, has fluctuated widely over the years, apparently due to the sensitivity of peach trees to weather fluctuations and their susceptibility to certain diseases (7).

The production of livestock and livestock products in Massachusetts has also shown market historical variations. The marketing of live animals for meat is a relatively small source of farm income in the State. Marketings

Figure 3
LAND IN FARMS, 1850-1980

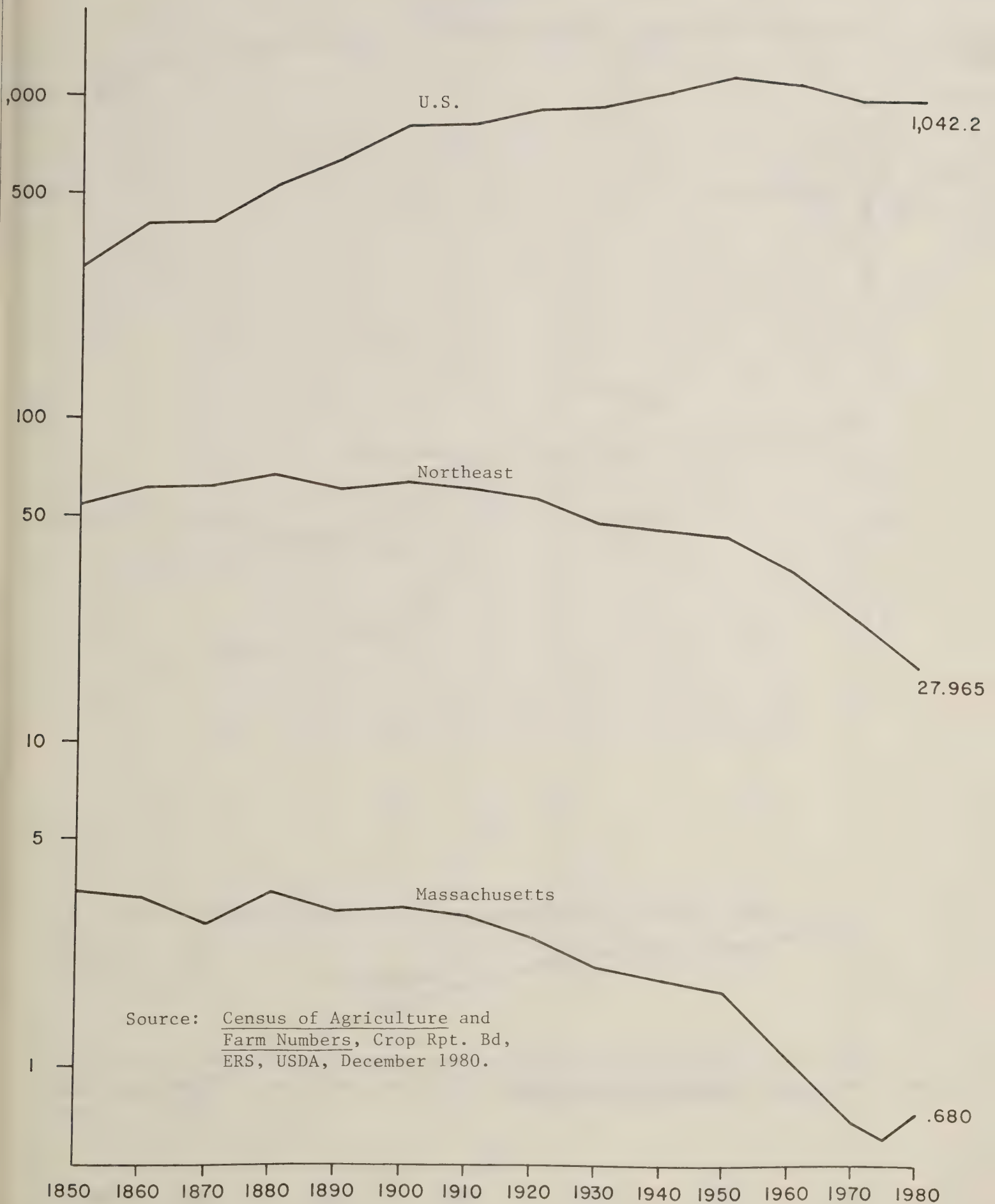


Figure 4
HARVESTED CROPLAND, 1920-1978
(millions of acres)

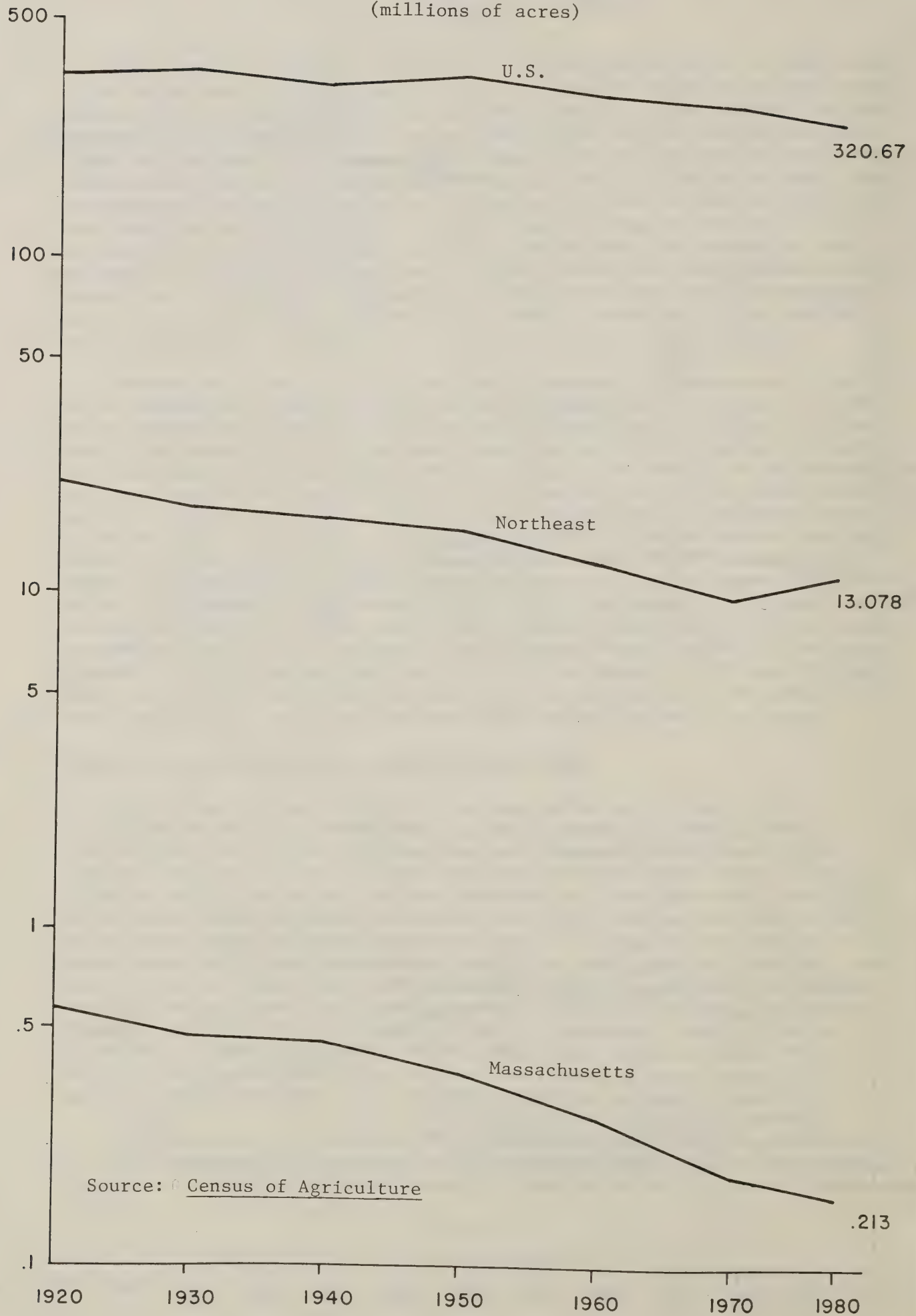
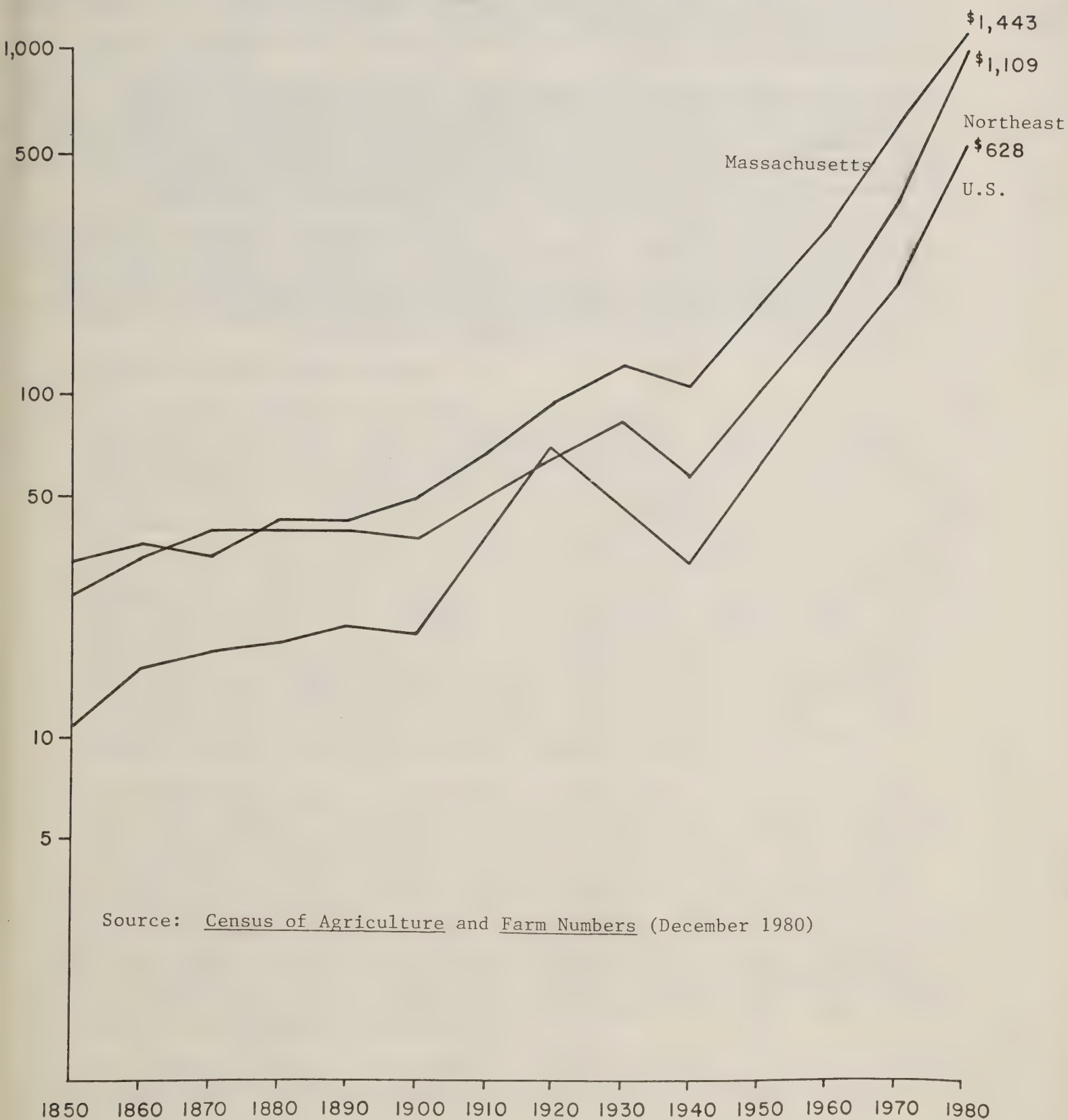


Figure 5
AVERAGE VALUE OF FARM REAL ESTATE PER ACRE, 1850-1978
(dollars)



Source: Census of Agriculture and Farm Numbers (December 1980)

of cattle and calves have fluctuated since 1930, with a decline during the 1970's. Significant growth in the production of hogs occurred during the 1950's, although since 1960 marketings have steadily declined. Production of sheep and lambs, which is a very small industry in the State, has shown wide variation.

Marketings of chickens, and particularly broilers, have exhibited an interesting pattern. The modern broiler industry in the U.S. began its development in the mid-1930's (33). The New England region was at the forefront of this early development. By 1950, the sale of broilers in Massachusetts exceeded that of all other chickens. After 1960, however, the State's broiler industry collapsed under competition from the South and Southeast, and is now virtually non-existent.

Output of eggs increased rapidly until 1950, and then also began to decline, although this decline has not been as dramatic as that of broilers. Milk production has fallen since 1960, despite continual increases in output per cow. An analysis of recent changes in the poultry and dairy industries, as well as other farm enterprises, is presented in the next three chapters.

CHAPTER IV

TRENDS IN FARM ENTERPRISE GROUPS, 1959-1974

CHAPTER SUMMARY

In both acreage and value of sales, dairying ranks as the most important farm enterprise group in Massachusetts. Poultry farms, other field crop farms, and livestock farms are also significant in terms of land use, while nursery/greenhouse and fruit farms rank second and third, respectively, in value of sales. The poultry and dairy enterprise groups experienced the most rapid declines in number of farms and land in farms between 1959 and 1978 and the outputs of vegetable, field crop, and livestock farms in the State have also fallen in comparison with the nation. In part, the loss of actively farmed land can be attributed to the fact that Massachusetts farmers have tended to specialize in those enterprises which produce commodities, for which demand has declined throughout the nation.

Definition of Enterprise Groups

In 1959, 1964, 1969, and 1974, the Census Bureau divided all commercial farms (those with gross sales of \$2500 or more) into a number of "enterprise groups" based on the Standard Industrial Classification of both agricultural and non-agricultural industries. ^{8/} Each farm is classified according to that product or class of products which constitutes 50 percent or more of its sales. For example, a farm which received more than 50 percent of its total receipts from the sale of vegetables is considered a vegetable farm, while one whose sales of milk represent more than 50 percent of total sales is classified as a dairy farm. A farm which sells a variety of products, none of which accounts for at least 50 percent of receipts, is classified as a general farm. Both in Massachusetts and the U.S. as a whole, general farms make up a very small percentage of all commercial farms. Most other farms are highly specialized, with their major product constituting well over half of total production. In Massachusetts, the percentages of total dollar output represented by the primary commodity range from a low of 84 percent for vegetable farms to a high of 98 percent for poultry and fruit and nut farms. ^{9/}

^{8/} Data for enterprise groups, while included in the 1978 Census of Agriculture, is not totally comparable to previous years census primarily due to the change in farm definition and in different enumeration procedures. However, through an agreement between the National Economics Division, ERS, USDA and the Agricultural Division of the Bureau of the Census, a special computer run was made on the Massachusetts 1978 Agricultural Census Data file to list number of farms, land in farms, and sales by selected enterprise groups which were composed of farms with a minimum of \$2500 dollars in sales, the limit for previous censuses. While budget and time constraints precluded a listing of all enterprise groups, comparabililty of Massachusetts data between census years 1974 and 1978 has been improved.

^{9/} The fruit and nut farm category is used by the Census Bureau on a national basis; however, no nuts are grown in Massachusetts.

In terms of land use, dairy farms comprise by far the most acreage (nearly 35%) followed by livestock farms (beef cattle, hogs, sheep), other field crops (including hay and potatoes), and fruit and nut farms (primarily cranberry bogs and orchards) (Table 6). Dairy products also account for the largest volume of sales (32%), followed by horticultural enterprises, fruit and nut farms, and poultry (Table 6). In this chapter, the competitive position of six enterprise groups will be analyzed: (1) fruit and nut, (2) vegetable, (3) other field crop (this category includes general farms, due to definitional changes in the census over the time period studied), (4) dairy, (5) poultry, and (6) other livestock farms. Greenhouse/nursery and tobacco farms have been excluded since they account for a small percentage of farmland and do not produce food crops per se. Data are provided for the years 1959, 1964, 1969, 1974, and 1978 for both Massachusetts and the United States.

Table 6--Standard Industrial Classification of Commercial Farms in Massachusetts, 1978 (1)

Enterprise Group	Acres	Percent of total acres	Value of sales (thousand dollars)	Percent of total dollars
Cash grain	1,899	.3	147	.1
Tobacco	3,379	.5	6,815	3.2
Other field crop	100,866	14.9	6,869	3.2
Vegetable	32,965	4.9	12,814	6.0
Fruit & Nut	86,869	12.8	30,349	14.1
Horticulture	16,237	2.4	41,181	19.1
General Crop	21,950	3.2	1,279	.6
Livestock	132,626	19.5	11,216	5.2
Dairy	235,024	34.6	68,466	32.0
Poultry & Eggs	10,703	1.6	18,688	8.7
Animal Specialty	13,675	2.0	14,771	6.9
General Livestock	10,071	1.5	725	.3
Miscellaneous	12,450	1.8	1,355	.6
TOTAL	678,714	100.0	214,675	100.0

Source: Census of Agriculture, 1978.

(1) Note: This includes all farms. Comparisons with previous census years include only those farms with \$2500 in sales a year or more.

Changes in Number of Farms, Land in Farms, and Value of Sales

No enterprise group, in either Massachusetts or the U.S., increased in number of farms between 1959 and 1974, although the number of fruit, vegetable, and other field crop farms did not decrease at as fast a rate in Massachusetts as they did nationwide (Table 7). However, between 1974 and 1978, those enterprise groups which represent more intensive uses of land did indeed increase. These increases were probably from farms that changed their principal commodity production in order to utilize the land resource more intensively (Tables 7 and 8). Dairy and poultry farms showed the largest rates of decline both in numbers and acreage. Since dairy farming is the largest agricultural enterprise in Massachusetts, the trends which that group exhibits tend to dominate the course of the agricultural sector as a whole.

In terms of value of sales nationwide, all enterprise groups showed substantial increases nationwide between 1959 and 1978 (Table 9) due to the effects of inflation, as well as to increases in total output. Growth in dollar output in Massachusetts kept pace with the national trend only in the case of fruit & nut farms. Again, dairy, and especially poultry farming, had declining sales and appear to be the least viable sectors within the State's agricultural economy, with sales of poultry products steadily declining despite a more than three-fold increase nationwide. The value of vegetable production did increase in Massachusetts but not as much as in the U.S.

Shifts have taken place in the relative economic importance of the various agricultural enterprise groups (Table 10). Between 1959 and 1974, the percentage share of output accounted for by all livestock products in Massachusetts shrunk from 63.3 percent to 52.9 percent, with a concurrent increase in the relative importance of all crops. Poultry declined most dramatically in importance, going from 23.4 percent of total farm sales in 1959 to only 8.8 percent in 1978. Dairy's importance also diminished, from a 33.6 percent share in 1964 to 28.7 percent in 1978. Because of declines in the livestock industries, fruits, vegetables, other field crops, and horticultural products all gained in importance. Nationwide, the relative share of livestock products dropped drastically between 1969 and 1974 due primarily to the large increase in grain production for export in the early 1970's (10). However, between 1974 and 1978, the livestock sector gained 7 percentage points (10).

Differential and Proportionality Shifts

One of the factors underlying the loss of agricultural land in Massachusetts may be that the distribution between enterprise groups results in specialization in those enterprises which have declined in acreage throughout the U.S. A nationwide decrease in the amount of farmland devoted to a particular enterprise can come about because of a general shift in consumer tastes (for example, per capita consumption of eggs, butter, and milk has decreased since 1970), or because of technological changes which serve to reduce the quantity of land required to produce a given level of output. The latter phenomenon has occurred often in the nation's agricultural history; examples are the introduction of the tractor which substituted for horse and mule power (and obviated the need for cropland and pasture that was required to support the work animals) and

Table 7--Changes in Number of Farms by Enterprise Group,
Massachusetts and the U.S.
1959-1978

	Fruit & Nut	Vegetable	Other : Field Crop : & General	Dairy	Poultry	Other : Livestock
<u>Massachusetts</u>						
	<u>- Number -</u>					
1978(1):	540	492	423	797	149	(2)
1974 :	485	378	312	914	187	283
1969 :	518	363	236	1251	399	259
1964 :	498	368	312	1986	820	233
1959 :	565	403	330	2817	1550	432

	<u>Index</u> (1959=100)					
1978(1):	96	122	128	28	10	(2)
1974 :	86	94	95	32	12	66
1969 :	92	90	72	44	26	60
1964 :	88	91	95	71	53	54
1959 :	100	100	100	100	100	100

:(1) 1978 data from Ag Census State file (Mass.) that excludes estimates from the direct enumeration sample for farms not on the mail list and those farms selling less than \$2500.

:(2) Comparable 1978 Agricultural Census data not available.

	<u>United States</u>					
	<u>- Number -</u>					
1978 :	75,419	35,325	156,852	168,187	49,748	(2)
1974 :	51,270	19,548	133,689	196,057	42,690	493,816
1969 :	53,754	19,660	157,717	260,956	57,545	647,884
1964 :	50,108	17,345	206,402	349,244	76,322	470,715
1959 :	61,419	21,912	249,945	428,293	103,279	684,061

	<u>Index</u> (1959=100)					
1978 :	123	161	63	39	48	(2)
1974 :	83	89	54	46	41	72
1969 :	88	90	63	61	56	95
1964 :	81	79	83	82	74	69
1959 :	100	100	100	100	100	100

:Note: 1978 U.S. data is not directly comparable to 1974 data since the 1978 data includes data for farm operations represented on the mail list plus estimates from the direct enumeration sample for farms not on the mail list. The 1974 data include only operations represented on the mail list.

Source: Census of Agriculture

Table 8--Changes in Land in Farms by Enterprise Group,
Massachusetts and the U.S.
1959-1978

			Other			
			Field Crop			Other
	Fruit & Nut	Vegetable	& General	Dairy	Poultry	Livestock
	<u>Massachusetts</u>					
	<u>- Acres -</u>					
1978(1):	77,032	29,792	62,465	227,013	8,567	(2)
1974 :	84,137	22,719	63,317	237,970	10,027	44,322
1969 :	88,033	23,093	45,005	279,729	21,022	47,334
1964 :	113,431	23,407	60,419	423,535	41,954	44,957
1959 :	97,193	22,461	44,867	559,627	70,676	57,425
	<u>Index</u>					
	<u>(1959=100)</u>					
1978(1):	79	133	139	41	12	(2)
1974 :	87	101	141	43	14	77
1969 :	91	103	100	50	30	82
1964 :	117	104	135	76	59	78
1959 :	100	100	100	100	100	100
	:(1) See footnote 1, Table 8.					
	:(2) Comparable 1978 Ag. Census data not available.					
	<u>United States</u>					
	<u>- Thousand acres -</u>					
1978 :	9,375	5,823	74,632	49,734	5,640	(2)
1974 :	7,625	4,698	68,328	54,077	5,468	442,394
1969 :	7,762	4,646	69,735	64,934	7,499	536,600
1964 :	8,792	4,676	82,970	83,296	9,527	514,236
1959 :	8,624	4,095	69,922	89,166	9,965	545,827
	<u>Index</u>					
	<u>(1959=100)</u>					
1978 :	109	142	107	56	57	(2)
1974 :	88	115	98	61	55	81
1969 :	90	113	100	73	75	98
1964 :	102	114	119	93	96	94
1959 :	100	100	100	100	100	100

Source: Census of Agriculture

(2) See footnote 2, Table 7.

Table 9--Changes in Value of Sales by Enterprise Group,
Massachusetts and the U.S.
1959-78

			Other			
			Field Crop			Other
	Fruit & Nut	Vegetable	& General	Dairy	Poultry	Livestock
	Massachusetts					
	-thousand dollars-					
1978(1):	29,322	10,802	2,556	59,789	18,023	(2)
1974 :	20,266	9,687	6,618	57,725	24,100	5,698
1969 :	17,617	7,120	3,717	44,636	24,601	4,494
1964 :	12,773	5,753	5,490	49,286	25,819	3,635
1959 :	9,563	4,928	4,115	44,730	30,625	4,783
	Index					
	(1959=100)					
1978(1):	304	219	62	134	59	(2)
1974 :	212	197	161	129	79	119
1969 :	184	144	90	100	80	94
1964 :	134	117	133	110	84	76
1959 :	100	100	100	100	100	100
:(1) See footnote 1, Table 8.						
:(2) Comparable Agricultural Census data for 1978 not available.						
	United States					
	-million dollars-					
1978 :	4,344	2,678	5,489	10,342	8,376	(2)
1974 :	2,717	1,795	4,142	7,675	6,005	32
1969 :	1,682	1,175	3,788	6,580	3,960	18
1964 :	1,616	857	3,909	5,355	2,919	9
1959 :	1,330	645	2,864	4,624	2,015	9
	Index					
	(1959=100)					
1978 :	327	415	192	224	416	(2)
1974 :	204	278	145	166	298	233
1969 :	126	182	132	142	197	188
1964 :	122	133	136	116	145	92
1959 :	100	100	100	100	100	100
:(2) See footnote 2, Table 7.						

Source: Census of Agriculture

Table 10--Percent Distribution of Total Value of Agricultural Products Sold,
Massachusetts, 1959-1978

	Massachusetts							United States			
	: 1978	: 1974	: 1969	: 1964	: 1959	: 1978	: 1974	: 1969	: 1964	: 1959	
Total Crops	: 47.0	: 48.2	: 44.8	: 39.9	: 36.2	: 45.1	: 51.4	: 37.1	: 46.0	: 43.5	
Field Crops, including hay and potatoes	: 3.9	: 4.4	: 3.0	: 4.3	: 3.4	: 30.0	: 38.0	: 23.7	: 26.3	: 23.7	
Tobacco	: 3.3	: 5.6	: 8.4	: 7.3	: 5.7	: 2.2	: 2.1	: 2.2	: 3.3	: 3.1	
Cotton	: 0	: 0	: 0	: 0	: 0	: 2.9	: 2.8	: 2.4	: 6.8	: 7.7	
Vegetables	: 6.4	: 5.8	: 5.5	: 4.8	: 4.3	: 3.0	: 2.9	: 2.9	: 2.8	: 2.4	
Fruit & Nuts	: 14.2	: 11.6	: 13.1	: 9.5	: 8.4	: 4.3	: 3.6	: 3.9	: 4.8	: 4.6	
Horticultural Specialties	: 19.2	: 20.9	: 14.8	: 14.0	: 14.4	: 2.7	: 2.1	: 2.0	: 2.0	: 2.0	
Forest Products	: N/A	: 0.4	: 0.3	: 0.4	: 0.5	: N/A	: 0.3	: 0.3	: 0.5	: 0.6	
Total Livestock Products	: 53.0	: 51.4	: 54.9	: 59.7	: 63.3	: 54.8	: 48.3	: 62.6	: 53.4	: 55.9	
Poultry & Poultry Products	: 8.7	: 13.5	: 18.1	: 19.1	: 23.4	: 7.9	: 7.7	: 8.7	: 8.7	: 7.4	
Dairy Products	: 28.7	: 28.5	: 29.1	: 33.6	: 32.4	: 10.4	: 10.2	: 12.2	: 13.1	: 13.2	
Cattle & Calves	: 5.9	: 4.2	: 4.6	: 3.8	: 4.1	: 27.6	: 22.7	: 31.5	: 23.1	: 25.7	
Sheep, Lambs & Wool	: -.1	: N/A	: N/A	: 0.1	: 0.1	: 0.6	: 0.6	: N/A	: 1.3	: 1.4	
Hogs & Pigs	: 2.6	: 1.9	: N/A	: 1.9	: 2.8	: 7.5	: 6.7	: N/A	: 6.6	: 8.0	
Other Livestock	: 7.0	: 3.3	: 3.1(1)	: 1.2	: 0.5	: .8	: 0.5	: 10.2(1)	: 0.6	: 0.2	
TOTAL	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	: 100.0	
N/A - not available	:	:	:	:	:	:	:	:	:	:	

Source: Census of Agriculture

the use of fertilizers and improved seed stocks which increased crop yields per acre. In recent years, increases in milk output per cow and per unit of feed consumed have been achieved, and confinement raising of livestock has reduced the land requirements of these enterprises (although in part, such reductions are offset by increases in grain production on crop farms, which supply the livestock farms). Indeed, land in dairy and poultry farms throughout the U.S. dropped significantly between 1959 and 1978 (Table 8), and these sectors represent two of Massachusetts' more important enterprise groups.

The question then arises: To what extent can agricultural decline in Massachusetts, as measured by land in farms or number of farms, be attributed to the State's mix of enterprise types; or, alternatively, to specific competitive disadvantages inherent in certain enterprise groups? One way to examine this problem is to estimate the differential and proportionality shifts for changes in farm numbers and farmland in Massachusetts between 1959 and 1974 (Table 11).

Table 11--Differential and Proportionality Shifts in Massachusetts Agriculture, 1959-74

	:	Farms	:	Land in Farms
	:	<u>Number</u>		<u>Acres</u>
Total Change	:	-3,968		-405,071
(expected)	:	(-2,134)		(-66,054)
Total Net Shift	:	-1,834		-339,017
(% of total change)	:	(46.2)		(83.7)
Net Differential Shifts	:			
Fruit	:	+13		- 1,797
Vegetables	:	+18		- 3,049
Other field crops	:	+126		19,533
Dairy	:	-376		-101,430
Poultry	:	-454		-28,754
Livestock	:	-29		-2,221
Other (1)	:	-289		-29,676
Total Net Differential Shift	:	-991		-147,394
Net Proportionality Shift	:	-843		-191,623

(1) Includes tobacco, horticultural, cash grain, and animal specialty farms.

First, the total net shift in agriculture is calculated, which is the difference between the actual change in total farm numbers or acres of farmland and the change which would have been expected if Massachusetts had exactly paralleled the national trend. For example, the total number of farms in the U.S. dropped from 2,416,017 in 1959 to 1,695,047 in 1974, a 29.8 percent decline. In Massachusetts the number of farms declined from 7,153 to 3,185 over this period, representing a loss of 3,968 farms (or a decline of 55.5 percent). If, however, the number of farms in Massachusetts had declined by 29.8 percent, only 2,134 farms would have been lost. Subtracting this "expected" change (-2,134) from the actual change (-3,968) yields the total net shift in number of farms (1,834). The total net shift in land in farms for Massachusetts is much larger (as a proportion of the total change) than the total shift in number of farms. This simply means that relative to national trends, the decline in land in farms was greater than the reduction in farm numbers. This finding is expected, since the average size of farms has not increased nearly as rapidly in Massachusetts as in the U.S. as a whole.

The next step is to calculate net shifts for each enterprise group individually in the same manner as the total agricultural net shift was derived. The percentage increase (or decrease) in farm numbers and land in each enterprise group is computed for the nation as a whole; the "expected" change in Massachusetts is then calculated; and this expected change is subtracted from the actual change which took place. The shifts for each enterprise group are termed "net differential shifts." A negative net differential shift means that the Massachusetts enterprise group declined more rapidly or grew more slowly than did the same sector nationally, while a positive net differential shift means that the enterprise group expanded faster or declined less severely in Massachusetts than in the nation as a whole. As the data show, only other field crop farms experienced a positive net differential shift in land and in farms, while fruits, vegetables, and other field crops showed positive shifts in number of farms.

Adding together the net differential shifts for each enterprise group yields the total net differential shift. This number can be interpreted as the extent to which the loss of farms and farmland in Massachusetts is attributable to locational or other competitive disadvantages unique to the State. Subtracting the total net differential shift from the total net shift for agriculture yields the net proportionality shift. The proportionality shift explains the degree to which the decline of agriculture can be ascribed to the State's specialization in those farm enterprises which have declined in numbers or acreage throughout the country.

Interestingly, the proportionality shift for land in farms is greater than the differential shift. In other words, the loss of farmland may be more a function of the enterprise mix in Massachusetts than of any other specific competitive disadvantage. The vast majority of the State's agricultural land in 1959 was used for dairy, poultry, and fruit production. All these enterprise groups experienced substantial declines in acreage nationwide over the 1959-74 period, and Massachusetts farms followed a similar pattern. If the State's farmers instead grew mostly cash grain crops, the proportionality shift would probably have been positive, since this is a high-growth sector in the U.S.

But, there is perhaps relatively little the State can do to drastically change the current enterprise mix in favor of high-growth sectors, since location factors and resource constraints limit the potential viability of certain types of farming.

The negative differential shifts, however, are also significant, and in fact dominate the total net shift in number of farms. Thus, even though the declines in some enterprises are partly reflective of national trends, the overall rate of loss of farms and farmland in Massachusetts exceeded that of the U.S. as a whole. This differential shift, which is greatest for dairy and poultry farms, can perhaps be explained by certain structural characteristics of Massachusetts farms, which are discussed in Chapter V.

CHAPTER V

FACTORS AFFECTING THE VIABILITY OF ENTERPRISE GROUPS

CHAPTER SUMMARY

Farm production costs are generally high in Massachusetts, due to the large volume of feed purchased by livestock farmers, (97% purchased from commercial mixers) relatively high labor requirements in most sectors, high land prices, high property taxes, and high prices for petroleum, fertilizers, and pesticides.

Dairy farming has also been hampered by the large land requirements associated with this pursuit. While the State's dairy farmers have maintained a competitive average farm size, land prices are very high, and less than one-quarter of dairymen were full owners of their farms in 1978. Small farm size and high land values also characterize the vegetable, field crop and livestock enterprises. The decline of poultry farming in Massachusetts is due primarily to the increased competition of the poultry sectors in the DelMarVa Peninsula and points further south.

Land Factors

Size of farms: As discussed in Chapter III, a combination of land tenure patterns, soil characteristics, and high farmland prices have kept the average farm size in Massachusetts well below that of the United States. In 1978, the average farm in Massachusetts was 114 acres in size, compared to 393 acres for the U.S. The trends in farm size from 1959 to 1978 vary by enterprise group, however (Table 12). Fruit and dairy farms in Massachusetts have maintained a

Table 12--Average Size of Farms by Enterprise Groups, 1978

	Fruit & Nut	Vegetable	Field Crop	Dairy	Poultry	Other Livestock
Massachusetts						
- acres -						
1978	177	51	122	281	52	104
1974	173	60	194	260	54	157
1969	170	64	156	224	53	183
1964	202	57	128	212	48	133
1959	172	56	106	199	46	133
United States						
- acres -						
1978	103	163	263 (1)	294	110	509
1974	149	240	478	276	128	896 (2)
1969	144	236	414	249	130	424
1964	154	202	359	227	116	411
1959	140	187	272	208	97	396
Massachusetts as Percent of the U.S.						
1978	114	31	46	96	47	20
1974	116	25	41	94	42	18
1969	118	27	38	90	41	43
1964	131	28	36	93	41	32
1959	123	30	39	96	47	34

(1) Excludes cotton and cash grain farms

(2) Includes livestock ranches omitted from other years

Source: Census of Agriculture

competitive size in comparison to the U.S. as a whole. On the other hand, vegetable and other livestock farms in Massachusetts are extremely small in comparison to their counterparts elsewhere, but these two enterprise groups show relatively small differential shifts. Therefore, it may tentatively be concluded that the presumed disadvantage of small farm size is not, in itself, a major cause of recent agricultural decline in Massachusetts. This is probably due to the fact that nearly half of these farm operators work off their farms 100 days or more a year. Because of the small farm size, however, in terms of revenues on these farms, Massachusetts suffers from a competitive disadvantage.

Value of Farm Real Estate: The average value of farm real estate per acre in Massachusetts substantially exceeds the value per acre in the U.S. for all enterprise groups, except fruit and nut farms. Land used for poultry and vegetable farming is particularly expensive, although these two enterprises have a high volume of sales per acre. The value of dairy real estate rose over five-fold in Massachusetts over the nineteen year period, and this trend was probably largely responsible for the reduction in land use for dairying.

High prices for farmland, which mostly reflect the extent of competing demands from non-agricultural uses, encourage farm owners to sell their land to the highest bidders which usually are non-agricultural users. This makes it difficult for other farmers, particularly those desiring to become established, to purchase it. Undoubtedly, the high real estate values in Massachusetts have and continue to contribute to the loss of agricultural land.

Productive Capabilities of Land: While prime farmland is relatively scarce in Massachusetts, less than half of it is currently in cropland use. Therefore, crop acreage could conceivably be expanded if economic conditions warranted it. But can Massachusetts farmers achieve yields comparable to those in other parts of the country? Potato output per acre is somewhat low in Massachusetts, but in the production of corn for silage, hay, sweet corn, and tomatoes, the State compares quite favorably to the U.S. as a whole (Table 13). Therefore, the expansion of crop farming would probably not be hampered by the physical limitations of the soil, at least in the short run. A more important factor regarding the potential expansion of agriculture is the distribution of productive land not currently being farmed relative to that of presently farmed land. There are 49 towns in the State (14 percent of the total number of towns) representing a relatively high concentration of agricultural land (142,694 acres of cropland, hay and pasture, orchards/nurseries and cranberries, representing 50 percent of such land found in the State). In addition, these same towns have 56 percent of all the animal units (e.g., animal unit is equivalent to one 1,000 lb. cow or 250 chickens or 100 turkeys, etc.). Thus, these 49 towns comprise a very large portion of the State's agricultural sector (Figure 6). Towns selected have at least 2500 acres of cropland,

Table 13--Yields Per Acre of Selected Crops in Massachusetts and the U.S.,
Average 1977-79

	Massachusetts	United States
Corn for silage (tons/acre)	16.5	13.4
All hay (tons/acre)	2.2	2.3
Potatoes (cwt./acre)	228.3	276.8
Sweet corn (cwt./acre)	77.3	79.8
Tomatoes (cwt./acre)	196.7	168.0

Source: U.S. Department of Agriculture, Agricultural Statistics, 1980

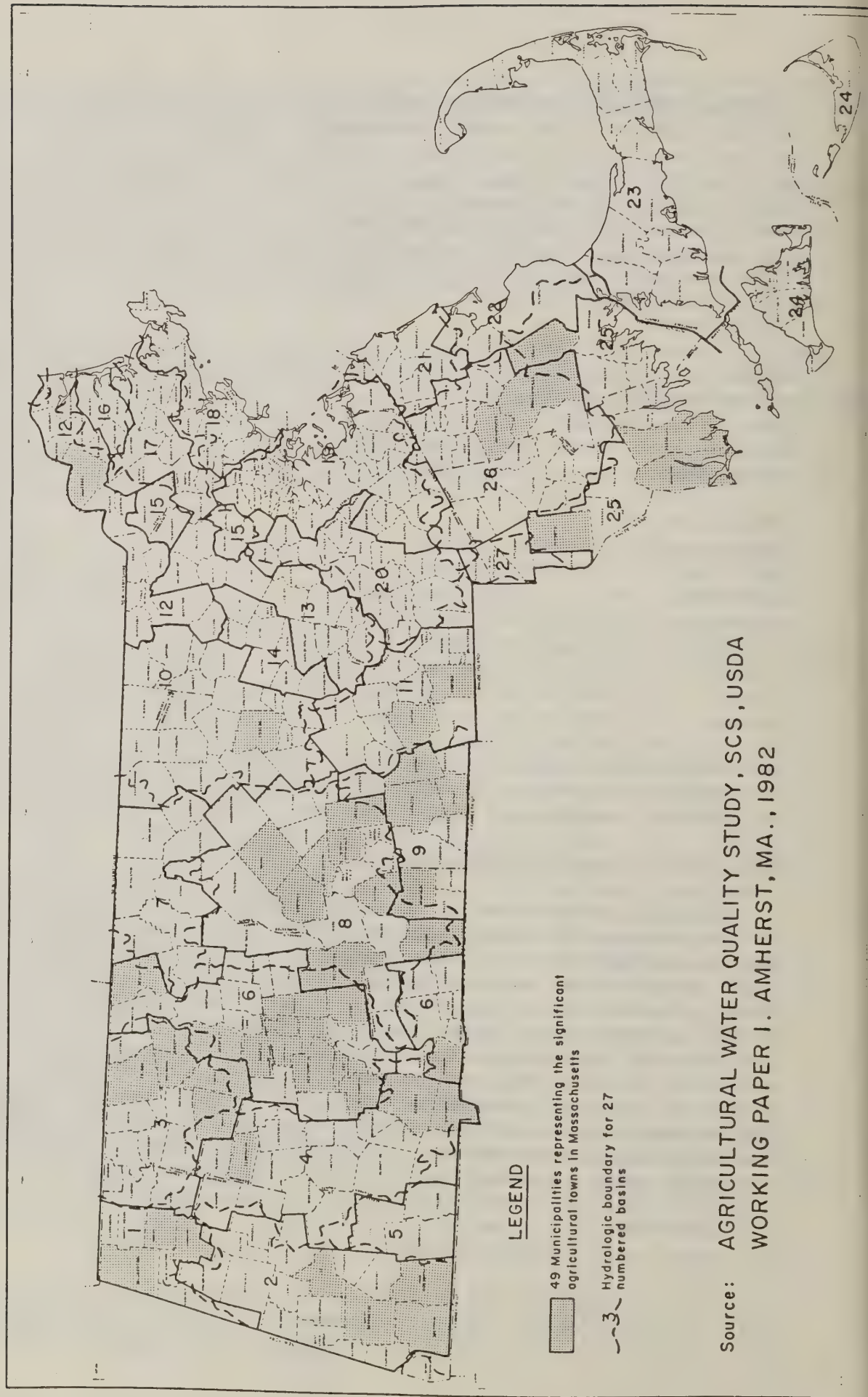
pasture, hayland and/or at least 900 animal units. Given the distributions of population and associated non-agricultural demands, any expansion of the agricultural sector will most likely occur in the western part of the State.

Characteristics of Farm Operators

Certain characteristics of farm operators can sometimes be used to predict the stability of the agricultural sector. For example, a relatively high average age of farmers, or a large proportion of farmers over the age of 55, indicates that pending retirement rates are relatively high, and may also indicate that the number of new and younger farmers entering agriculture are relatively low. As the average age of farmers increase, there is a greater probability that more agricultural land will be sold for non-agricultural uses. A large proportion of part-time farmers usually signifies that farming is no longer economically viable as a primary occupation. However, this conclusion in Massachusetts is due primarily to availability of off-farm jobs, and small average farm size. Another potential indicator of agricultural decline is the rate of land ownership among farmers. If most farmers rent part or all of their land, this indicates that real estate prices are prohibitively expensive for the farmers. And landowners who do not farm may be more apt to sell their agricultural land for development purposes if market conditions are favorable.

Age of Farmers: The average age of farm operators increased from 1959 to 1978 in all enterprise groups, although this trend characterized farmers throughout the U.S. as well (Table 14). Perhaps more importantly, the mean age of

FIG. 6 Significant Agricultural Towns,
Massachusetts, 1980.



Source: AGRICULTURAL WATER QUALITY STUDY, SCS, USDA
WORKING PAPER I. AMHERST, MA., 1982

Table 14--Average Age of Farm Operators by Enterprise Group

	Fruit & Nut	Vegetable	Other Field Crop	Dairy	Poultry	Other Livestock
Massachusetts						
- Years -						
1978	53.9	54.0	53.7	51.9	51.6	51.3
1974	57.7	53.0	55.0	52.6	55.5	55.3
1969	54.5	53.0	55.6	52.4	53.9	52.9
1964	N/A	N/A	N/A	N/A	N/A	N/A
1959	55.9	51.5	50.9	51.2	52.8	49.3
United States						
- Years -						
1978	52.7	51.1	50.1	47.8	49.2	51.2
1974	54.9	51.9	51.7	49.3	50.6	52.1
1969	53.4	50.8	48.8	48.8	50.1	50.7
1964	N/A	N/A	N/A	N/A	N/A	N/A
1959	52.9	49.0	46.9	47.9	49.9	49.4

N/A - not available

Source: Census of Agriculture

farmers in Massachusetts is in all cases higher than the mean age nationwide, as is the proportion of farmers over age 55 in 1974. The differences are strikingly different for dairy and poultry farmers. Three conclusions can be derived from age statistics in Massachusetts:

1. Provides a sign that for one or more reasons (high cost of feed, high start-up costs, etc. relative to farm income) these types of farms may not generate adequate net farm income and thus fewer, younger farmers enter into these forms of agricultural groups.
2. Many senior farmers, because of their age and expectations as to their future ability (in physical terms) to continue to operate the farm, have shorter planning horizons and are less willing to make long-term capital investments because they would not be able to reap the benefits of such investments. As a result, operational efficiencies do not increase.
3. As the average age of these farmers continues to increase, the probability that there will be a continued decrease in these types of farms increases as more and more farmers reach retirement age.

Part-time Farming: The percentage of part-time farmers is not in general any greater in Massachusetts than elsewhere; in fact, poultry farmers in the State are much less likely to work 100 days or more off the farm than poultry farmers nationwide. It is interesting to note that many more fruit, vegetable, field crop, and livestock farmers worked off the farm in 1978 than in 1959, both in Massachusetts and the U.S. This trend, however, was reversed for dairy and poultry farmers, particularly in Massachusetts, primarily because the manner in which dairy and poultry operations are conducted in the State precludes, in many cases, the time available for part-time work.

Land Tenure: Rates of full ownership have been consistently higher in Massachusetts than the U.S. in all enterprise groups, except, significantly, dairy (Table 15). In fact, the proportion of Massachusetts dairy farmers who were full owners dropped from 43.8 percent in 1959 to 31.3 percent in 1974 to 24.2 percent in 1978 while nationally the proportion remained over 44 percent in 1978. This finding is not surprising, since dairy enterprises require relatively large amounts of land, and farmland prices are high in Massachusetts. As a result, dairy farmers in the State have found it increasingly necessary to lease at least part of their land in order to maintain a competitive size. This situation has undoubtedly promoted the decline of dairy farming in the State, primarily because renting does not guarantee long-term availability of farmland and thus discourages capital improvements in the farm enterprise.

Table 15--Percent of Farm Operators Who Were Full Owners of Their Farms,
by Enterprise Group

	:	:	:	Other	:	:	:	Other				
	:	Fruit & Nut	:	Vegetable	:	Field Crop	:	Dairy	:	Poultry	:	Livestock
	:	- <u>Percent</u> -										
	:											
	:	Massachusetts										
	:											
1978	:	83.8	:	63.7	:	68.6	:	24.2	:	84.0	:	73.0
1974	:	85.6	:	53.2	:	60.2	:	31.3	:	86.1	:	67.5
1969	:	85.3	:	48.2	:	41.1	:	38.8	:	89.2	:	69.5
1959	:	80.7	:	45.9	:	49.6	:	43.8	:	91.8	:	71.8
	:											
	:	United States										
	:											
1978	:	86.2	:	56.8	:	58.3	:	44.6	:	78.6	:	56.7
1974	:	82.8	:	48.9	:	54.1	:	51.3	:	81.6	:	59.7
1969	:	80.6	:	43.6	:	34.7	:	55.8	:	81.6	:	56.1
1964	:	75.5	:	46.3	:	32.8	:	53.9	:	78.0	:	53.9
1959	:	76.1	:	44.9	:	34.9	:	55.2	:	79.4	:	51.4
	:											
	:											

Source: Census of Agriculture

Production Costs

Production Coefficients: The ratio of total production costs to gross farm income is, of course, a major indicator of the comparative economic viability of agriculture in one region vs. another. The 1974 and 1978 agricultural censuses provide data on production costs for each enterprise group, broken down into several categories. ^{10/} This information was used to generate production coefficients for Massachusetts and the U.S. (Table 16). The coefficients for each enterprise group were derived by dividing the expenditures for each input by the total volume of sales, and multiplying by 100. Each coefficient therefore describes the cents per dollar of output used to purchase a given input. Comparing the production costs of Massachusetts farmers to those in the U.S. provide useful insights into the competitive position of the State's farmers. However, the reader is cautioned not to make rigid comparisons, since differences in the composition of inputs may be due primarily to differences in the product mix of each enterprise group. For example, other field crop farms in Massachusetts consist mostly of hay and potato farms, but nationally this category also includes peanut and sugar crop farms; similarly, fruit and nut farms in Massachusetts are primarily cranberry farms and orchards, while nationally this category encompasses farms producing a variety of tropical and northern fruits as well as nuts, which are not grown in Massachusetts.

Total production expenses are relatively high in Massachusetts for all crop groups, except fruit and nuts. Crop farms in Massachusetts spend relatively more on petroleum products, hired labor, and other expenses (which include, among other things, taxes, interest, depreciation, and cash rent) than do farmers elsewhere. Other field crop farms also have higher seed, fertilizer, and pesticide costs.

Both dairy and other livestock farms had much higher production costs relative to total sales in 1978 than the U.S. farmers as a whole. In fact, Massachusetts livestock farmers were unable, on the average, to break even. The biggest problems appear to be the large expenditures on feed and hired labor, as well as other (miscellaneous) expenses for livestock farms.

Aggregate production costs, however, tell only part of the story. The question then arises: Are higher costs due to higher prices per unit for each input or do they arise because farmers in Massachusetts must buy relatively larger quantities of inputs to be productive? A review of price data suggests that both of these situations face Massachusetts' farmers relative to their counterparts elsewhere (Table 17). In addition, for the most part, Massachusetts farmers, because of quantity and quality problems receive lower prices for their produce with the exception of a few commodities (Table 18).

Property Taxes: The most extreme difference between Massachusetts and the U.S. is found in the property tax rate. In 1978, property taxes in the State averaged nearly \$20 per acre, compared to \$3.34 nationwide. High taxes help to explain the rather sizable production coefficients for "other" inputs

^{10/} Other expenses were estimated. See Table 18.

Table 16--Commercial Crop and Livestock Farm Production Coefficients, 1978
(Selected production expenses ÷ value of sales x 100)

	Fruit & Nut		Vegetable		Other		Dairy		Poultry		Other	
	Mass.	U.S.	Mass.	U.S.	Mass.	U.S.	Mass.	U.S.	Mass.	U.S.	Mass.	U.S.
Livestock purchase	.15	.28	.21	.35	1.63	1.94	6.04	5.39	7.52	14.90	27.27	34.73
Feed	.53	.39	.55	.36	3.02	1.37	32.28	25.23	55.48	52.01	28.37	19.00
Seed	.91	1.04	4.48	3.11	5.91	4.37	.90	1.52	.11	.14	1.16	1.18
Fertilizer	2.06	4.02	7.16	6.64	12.95	10.24	4.58	4.09	.43	.45	4.45	3.66
Agricultural Chemicals:	4.75	4.74	4.29	4.77	6.07	4.41	1.20	1.15	.08	.22	1.80	1.30
Energy & Petroleum Products	5.19	4.50	8.08	4.39	10.77	8.17	5.48	5.10	5.57	2.43	9.92	4.31
Hired Labor	23.68	18.89	21.36	18.52	10.41	11.04	10.01	5.75	9.89	3.72	8.79	3.06
Contract Labor	2.77	7.48	2.12	5.01	.88	1.53	.19	.20	.70	.21	.77	.24
Machine Hire	1.26	3.18	.50	1.73	1.32	2.98	.39	.96	.06	.19	1.22	1.11
Other Expenses(1)	32.72	29.91	37.14	30.86	34.75	34.96	26.20	25.59	16.04	9.92	26.78	17.95
Selected Production Expenses	74.02	74.43	85.89	75.74	87.71	81.01	87.57	74.98	95.88	84.19	110.53	86.54

(1) Includes taxes, depreciation, interest, cash rent, insurance, repairs, electricity, purchase of water, veterinary services, or any other current operating expenses. These are estimated for 1978 by computing the percent of other expenses to selected expenses for 1974, and multiplying that result times the total 1978 selected expenses. This assumes that the proportional relationship of other expenses to selected expenses remained constant between 1974 and 1978.

Source: 1974 and 1978 Censuses of Agriculture

Table 17--Average Annual Prices Paid by Farmers for Selected Inputs,
1974 and 1978

	Massachusetts		United States	
	1978	1974	1978	1974
Farm Wage Rates (dollars per hour)	2.88	2.40	3.09	2.25
Farm Property Tax Rates (dollars per acre)	19.64	16.12	3.34	2.70
Regular Gasoline, Bulk Delivery (cents per gallon)	62.0	49.6	59.7	46.5
Mixed Fertilizer, 10-10-10 (dollars per ton)	117(1)	135	111	113
Ammonium Nitrate (dollars per ton)	169(1)	218	138	155
Herbicide, Atrazine (dollars per pound)	2.14(1)	2.40	2.01	2.34
Insecticide, Parathion (dollars per gallon)	18.50(1)	13.50	10.48	7.52
Dairy Feed, 16% Protein (dollars per 100 lbs.)	6.74	6.74	6.90	6.88
Hog Feed, 14-18% Protein (dollars per 100 lbs.)	NA	8.17	-	8.33
Poultry (Laying) Feed (dollars per 100 lbs.)	7.29	7.28	7.59	7.69

NA - Not Available

(1) For New England as a whole; data not available for Massachusetts.

Sources: USDA, Farm Labor; Agricultural Statistics; and Agricultural Prices

Table 18--Average Annual Prices Received for Selected Products,
1974 and 1978

	:	Massachusetts		:	United States	
	:	1978	1974	:	1978	1974
Apples	:					
(season average,	:					
cents per lbs.)	:	14.0	15.7	:	13.8	11.6
All Hay	:					
(season average,	:					
dollars per ton)	:	73.00	63.00	:	50.30	50.60
Potatoes	:					
(season average,	:					
dollars per cwt.)	:	5.90	3.50	:	3.56	4.35
Milk	:					
(dollars per 100 lbs.)	:	11.50	9.25	:	10.60	8.31
Eggs	:					
(cents per dozen)	:	66.2	64.5	:	52.2	53.3
Calves	:					
(dollars per 100 lbs)	:	57.00	28.00	:	59.10	35.20
Hogs	:					
(dollars per 100 lbs.)	:	45.00	33.00	:	46.60	34.10

Source: USDA, Agricultural Prices

for most enterprise groups. In 1978, Massachusetts farmers on the average spent about 6.2 percent of their income on property taxes, compared to 3.2 percent nationwide. 11/

Labor: The State's farm wage rates were also somewhat high in 1974, although by 1978 wages were actually lower in Massachusetts than in the U.S. as a whole. Furthermore, the inequality of wage rates in 1978 was not substantial enough to fully explain the differences in expenditures on labor exhibited by most of the enterprise groups. Therefore, farmers in Massachusetts probably use relatively more labor per unit of output than farmers elsewhere, a finding which is consistent with the proposition that small farms are less capital intensive (and hence more labor intensive) than larger farms.

11/ These figures were derived by multiplying the average tax rate in 1978 by total acres of land in farms, and dividing this figure by total volume of sales, for both Massachusetts and the U.S.

Gasoline, Fertilizer, and Pesticide Prices: Gasoline prices are slightly higher in Massachusetts, which may partly account for the relatively large expenditures by all three crop enterprises on petroleum products. Fertilizer and pesticide prices are also higher in Massachusetts than in most other parts of the country, including the other New England States. ^{12/} The production coefficients, however, are generally lower for these input categories (except in the case of other field crop farms), suggesting that farmers in the State use fewer chemicals than those nationwide.

Feed Costs: Feed prices are relatively high in Massachusetts (19.5 percent above the national average) ^{13/} and that, together with the fact that most of the dairy feed is purchased from commercial mixers, results in the State's dairy and other livestock farmers spending much more on feed as a proportion of income than do most farmers in the U.S. The high production coefficients are explained by the small volume of grain produced on livestock farms in Massachusetts, which forces farmers to purchase nearly all their feed from outside suppliers. In 1980, 97 percent of the rations fed to milk cows in Massachusetts were purchased commercially mixed feeds, compared to only 40 percent nationwide. ^{14/} Thus, it is the price and quantity of feed which must be bought that elevates production costs of Massachusetts dairy and livestock farmers. In order to reduce the total cost of feed, farmers have increased production of corn for silage in recent years (³³).

Prices Received

For the most part, farmers in Massachusetts receive competitive prices for their products; in fact, revenues per unit for hay, potatoes, milk, and eggs are significantly higher in the State than in the nation as a whole (Table 18). Therefore, farmers marketing these products can be considered to have a competitive advantage in this respect, one which can be attributed to close proximity to markets. However, relative to prices paid by farmers for inputs, the seeming advantage is somewhat muted.

Farm Productivity

Changes in the productivity, or efficiency, of the farm sector in Massachusetts have been estimated for the 1959-1974 period, using methods similar to those developed by USDA to calculate aggregate productivity indexes for the major regions of the U.S. (⁴⁹). Due to a variety of difficulties involved in assembling all the relevant input and output data at the State level, the Massachusetts indexes are not strictly comparable to the national or regional indexes. Nevertheless, they do indicate the extent to which trends in agricultural productivity in the State parallel the more general regional or national trends.

^{12/} The New England Crop Reporting Service collected information on fertilizer prices for a sample of 53 dealers in Massachusetts between December 1979 and May 1981; twelve of these observations were equal or lower in value than the mean New England fertilizer price, but prices offered by the remaining 43 dealers were higher than the mean New England price. Since, however, the Massachusetts observations do not represent a random sample, one cannot conclude definitively that Massachusetts farmers pay more for fertilizer than those elsewhere in New England.

^{13/} USDA Crop Reporting Board, Nov, 1980.

^{14/} Ibid, May, 1980.

Productivity indexes for Massachusetts, the Northeast region, and the U.S. measure three different types of productivity: land, labor, and multifactor. Land productivity is defined simply as the value of output of crops per acre of farmland, while labor productivity measures total output (the value of all crops and livestock) per hour of farm labor employed. Multifactor productivity indexes attempt to measure overall efficiency; i.e., changes in the ratio of all output to all inputs over time. The input categories used to construct the multifactor indexes include: labor; real estate; machinery and mechanical power; agricultural chemicals; feed, seed, and livestock purchases; and taxes and interest. All the productivity indexes measure changes in quantities of inputs and outputs; prices of inputs are held constant at arbitrarily selected base year levels, (in this case, the average 1967-69 prices). Thus, productivity indexes address the quantity side of costs and revenues rather than the price considerations.

Crop production per acre has increased significantly faster in Massachusetts than in the Northeast or the U.S., while labor productivity has also increased, but at a slower rate (Table 19). In addition to improved farming techniques

Table 19--Land, Labor, and Multifactor Productivity Indexes
(1959 = 100)

	:	Massachusetts	:	Northeast	:	United States
	:		:		:	
	:	<u>Crop Production Per Acre of Cropland -</u>				
1974	:	169	:	121	:	123
1969	:	164	:	125	:	125
1964	:	134	:	110	:	113
1959	:	100	:	100	:	100
	:	<u>- Output per Hour of Farm Labor -</u>				
1974	:	149	:	228	:	230
1969	:	145	:	175	:	185
1964	:	119	:	132	:	137
1959	:	100	:	100	:	100
	:	<u>- Multifactor Productivity -</u>				
1974	:	135	:	130	:	123
1969	:	128	:	123	:	119
1964	:	122	:	111	:	110
1959	:	100	:	100	:	100

Source: Massachusetts figures derived from Appendix A; data for the Northeast and U.S. from USDA, Changes in Farm Production and Efficiency, 1978

leading to higher yields per acre, the rapid growth in cropland productivity in Massachusetts can be attributed to the abandonment of less productive land and to ever-increasing land values, which forces farmers to grow proportionately, higher valued crops. Increases in labor productivity, both in Massachusetts and the U.S. as a whole, have been brought about primarily through the adoption of improved farm management techniques and the substitution of capital (machinery and equipment) for labor. As might be expected, labor productivity has not risen as fast in Massachusetts as in the Northeast or the U.S., since the relatively small size of farms often precludes highly capital-intensive farming methods.

In terms of overall (multifactor) productivity, the Massachusetts trend compares favorably with that of the Northeast and the U.S. In part, however, the improved efficiency of Massachusetts farms is due to the relatively high attrition rate of less productive farmers and a shifting to more intensive use of land. Nevertheless, this trend suggests that a leveling off of agricultural decline in Massachusetts is occurring primarily because the farms that remain are, for the most part, relatively competitive.

CHAPTER VI

PRODUCTION TRENDS IN MASSACHUSETTS AND COMPETING STATES

CHAPTER SUMMARY

Farmers in States which compete with Massachusetts for the Boston area consumer market have typically claimed relatively larger shares of the market over time, with the largest producers continuing to gain importance. The decline in the competitive position of Massachusetts poultry farmers has been especially severe. Broiler production in the State, for all intents and purposes, disappeared during the 1960's when the industry became vertically integrated and highly concentrated in areas with milder climates, low labor costs, and better access to feed sources. A similar trend occurred in egg production, although since this commodity requires little processing and is therefore more market-oriented, egg farming has remained viable in Massachusetts.

Definition of Competing States

In this chapter, trends in the production of selected agricultural commodities in Massachusetts are analyzed in relation to trends in other States which compete with Massachusetts for the Boston area consumer market. In many cases, these "competing" States represent the largest and most efficient producers of each commodity. For apples, vegetables, and potatoes, competing States are defined as the major points of origin in 1978 for truck and rail shipments to Boston terminals. ^{15/}

Since Massachusetts currently has a monopoly on unloads of cranberries in Boston, the other States listed represent the three largest producers in the U.S. (other than Massachusetts). Likewise, since interregional trade information was not available for dairy products and eggs (which are important agricultural products in Massachusetts), the "competing" States listed represent other major producers. In the case of dairy products, the three States chosen are the largest suppliers of fluid milk (other than Massachusetts) in the New England Federal milk marketing area and New York; for eggs, the two largest producers in the U.S. plus the largest producer in the Northeast were selected for comparison.

Crops Examined

Cranberries: Massachusetts is the nation's largest cranberry producer, although from 1959 to 1978, acreage in cranberries in the State declined slightly (Table 20). Cranberry production has remained relatively stable over time in New Jersey and Washington, while Wisconsin is the only major producer which has shown relatively rapid growth in this commodity. Wisconsin's growth is probably due to high yields per acre, which averaged 126 barrels per acre between 1977 and 1979, compared to 93 barrels per acre in Massachusetts (44). Farm wage rates are also lower in Wisconsin, on the average, than in New England (47). Nevertheless, the cranberry industry in Massachusetts is still economically strong, forming the mainstay of the State's fruit industry. Much of the consistency in production during the last few years is a direct result of the Ocean Spray Cranberry Cooperative which now markets nearly all cranberries nationwide.

Apples: Apple production declined by 30 percent in Massachusetts between 1959 and 1974, but then increased from 1974 to 1978 (Table 21). Fluctuations in production

^{15/} Unpublished data on shipments of fruits and vegetables were obtained from the National Economics Division, Economic Research Service, U.S. Department of Agriculture.

Table 20--Acres Harvested of Cranberries in Massachusetts
and Competing States, 1959-1978

	Massachusetts	New Jersey	Washington	Wisconsin
	- Acres -			
1978	11,200	3,000	1,100	7,000
1974	10,900	3,200	1,100	7,000
1969	11,100	3,000	1,000	5,400
1964	11,700	3,100	1,000	4,300
1959	12,800	2,800	1,000	4,200
	Index (1959=100)			
1978	88	107	110	167
1974	85	114	110	167
1969	87	107	100	129
1964	91	111	100	102
1959	100	100	100	100

Source: USDA, Agricultural Statistics

Table 21--Apple Production in Massachusetts and Exporting States,
1959-1978

	Massachusetts	New Hampshire	New York	Washington
	- Thousand bushels -			
1978	2,186	1,250	22,500	44,750
1974	1,896	1,271	18,521	37,625
1969	2,083	792	17,813	34,896
1964	2,800	1,180	22,500	26,000
1959	2,700	1,630	19,500	23,650
	Index (1959=100)			
1978	81	77	115	189
1974	70	78	95	159
1969	77	49	91	148
1964	104	72	115	110
1959	100	100	100	100

Source: USDA, Agricultural Statistics

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and Competing States, 1959-1978

	Massachusetts	New Jersey	Washington	Wisconsin
	- Acres -			
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1969	11,100	3,000	1,000	5,400
1964	11,700	3,100	1,000	4,300
1959	12,800	2,800	1,000	4,200
	Index (1959=100)			
1978	88	107	110	167
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1959	100	100	100	100

Source: USDA, Agricultural Statistics

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	Index (1959=100)			
1978	81	77	115	189
1974	70	78	95	159
1969	77	49	91	148
1964	104	72	115	110
1959	100	100	100	100

Source: USDA, Agricultural Statistics

harvest has increased and Florida's has remained about the same. 16/ A study conducted by the Massachusetts Community Economic Development Assistance Corporation stated unequivocally that the overall quality of produce in the New England region was such that prices received by farmers were in some cases one-half that received by out-of-State shippers. In addition, the wholesale market (in Massachusetts, the Chelsea Market) is usually biased toward large lot deliveries of a consistent quality which Massachusetts vegetable farmers cannot provide primarily because of small farm size and a lack of post-harvesting processing (hydrocooling, intermediary storage, etc.). Thus, it appears that the competitive position of Massachusetts vegetable farmers in relation to the major producers will continue to erode unless quality of product is increased. Climate is another obvious factor, with Florida and California not only achieving higher yields per acre but also producing several crops per year. The vegetable processing and wholesaling industry has also shifted from traditional market orientation to locations in high density producing areas, especially California. The lack of processing outlets has created marketing problems for some farmers in Massachusetts and other northern States (33). In addition to marketing problems, the lack of a vigorous processing/wholesaling infrastructure has also resulted in a lack of economic incentives for farmers to upgrade quality. This is due to the fact that most processors/wholesalers operate on a two or more pricing tiers wherein premium quality products receive higher prices than lower quality products. Relatively high fertilizer and insecticide prices also characterize Massachusetts' vegetable farmers in comparison with California and Florida vegetable farmers (46).

In comparing Massachusetts vegetable farms with those in California, the land constraint to vegetable production volumes and commensurate farm income becomes obvious. When particular vegetable farm characteristics are compared, the net return to an average Massachusetts vegetable farm is significantly smaller than the U.S. and California averages. As a result, Massachusetts vegetable farmers may not be able to effectively compete for the necessary amounts factors of production (land, labor, capital) relative to the non-agricultural demands on these factors of production. The average size of vegetable farms in Massachusetts, California, and in the U.S. are 50 acres, 474 acres, and 163 acres, respectively. But in terms of the number of harvested acres per farm, Massachusetts averages 22 acres, California 375 acres and the U.S. 101 acres. Gross sales receipts per harvested acre per each geographic area are \$784, \$1116, and \$754, respectively. Net returns (gross cash receipts less selected expenses 17/) are \$348 in Massachusetts, \$544 in California, and \$365 in the U.S. Multiplying these amounts times the average number of harvested acres, result in average net returns per farm amounting to \$7656 in Massachusetts, \$204,000 in California

16/ This decline in vegetable acreage in Massachusetts, as reported by USDA (44) conflicts with Census of Agriculture data, which show relative stability in acreage devoted to vegetables over this period. USDA relies on sampling techniques to collect its data, and the sample probably contains a disproportionate number of large producers, whereas census data encompasses all producers regardless of size.

17/ Selected expenses include dollars spent on seed, bulls, plants, commercial fertilizer; other ag chemicals; energy and petroleum products; hired farm labor; contract labor; custom work and machine hire. Depreciation, taxes, interest, and repairs are not included in the analysis.

and \$36,865 in the U.S. Thus, in examining farms as an economic entity, Massachusetts vegetable farms certainly experience far less net income than their counterparts in California and in the nation, and as a result, are less capable of effectively bidding for factors of production demanded by other agricultural and non-agricultural firms. As a result, a great many vegetable farmers require off-farm employment.

The high value of farm real estate further compounds the farm size problem in that given the returns per acre, farmers who wish to expand their operation and thereby increase total net returns find such an undertaking financially difficult in that earnings per acre are not large enough to permit expansion. Relative to the U.S. and other agricultural States, the land input in Massachusetts on a cost basis is higher, and as a result, net returns and thus farm income are lower. In spite of this, Massachusetts vegetable farmers do enjoy the advantage of proximity to a large consumer market and certain fresh vegetables will undoubtedly continue to be produced.

Potatoes: In potato production, only Idaho, the nation's largest producer, has maintained steady growth in harvested acreage (Table 23). Land used to grow potatoes has declined by nearly 50 percent in Massachusetts, but California has also sustained substantial losses, as has Maine since 1969. Yields per acre in Idaho exceed those in Massachusetts (an average of 265 cwt./acre in Idaho between 1977 and 1979, compared to 228 cwt./acre in Massachusetts). Also, the high quality of Idaho potatoes and an effective marketing campaign have stimulated consumer demand. In 1978, the average price received by potato

Table 23--Acres Harvested of Potatoes in Massachusetts
and Exporting States, 1959-1978

	Massachusetts	California	Idaho	Maine
	- acres -			
1978	3,600	57,200	355,000	118,000
1974	4,000	70,500	342,000	140,000
1969	5,000	91,900	317,000	156,000
1964	6,800	89,500	246,000	145,000
1959	6,800	98,100	210,400	142,000
	Index (1959=100)			
1978	53	58	169	83
1974	59	72	163	99
1969	74	94	151	110
1964	100	91	117	102
1959	100	100	100	100

Source: USDA, Agricultural Statistics

farmers in Idaho was only \$2.60 per hundred-weight, compared to \$6.66 in California, \$3.20 in Maine, and \$5.90 in Massachusetts. These price differences basically reflect the relative proximity to markets. Transport costs are relatively high for potatoes, so Massachusetts and California farmers, who are close to markets, receive higher prices.

Milk: Milk output in Massachusetts has fallen by more than 25 percent since 1959 (Table 24). Connecticut's output has also declined, while production has risen in the less heavily urbanized States of New York and Vermont. Dairy farming is typically more vulnerable to the effects of urbanization than many other agricultural enterprises (11). It is difficult to meet the relatively high land requirements of this enterprise type where land prices are high, and dairy farming also requires substantial long-term capital investment, which farmers may be reluctant to make in the face of approaching urban development (see discussion of the "impermanence syndrome" in Chapter VII). In addition, dairy farms have traditionally been located near markets, i.e., urban areas, and are therefore often directly in the path of suburban development. Another problem facing dairy farmers in Massachusetts is that 97 percent of the feed consumed by the livestock is purchased rather than grown on the farm, compared to 92 percent in Vermont and only 61 percent in New York. Farmers have increased silage production in recent years in an attempt to lower production costs, but further expansion of output may be limited by a lack of suitable cropland. On the positive side, Massachusetts farmers have access to a large consumer market and receive higher prices relative to other New England States.

Table 24--Milk Produced in Massachusetts
and Competing States, 1959-1978

	:	:	:	:				
	:	Massachusetts	:	Connecticut	:	New York	:	Vermont
	:	:	:	:	:	:	:	:
1978	:	571		612		10,408		2,136
1974	:	593		613		9,822		1,945
1969	:	681		679		10,444		1,920
1964	:	811		711		10,914		2,011
1959	:	782		733		9,759		1,781
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Source: USDA, Agricultural Statistics

It should be noted however that milk sold in Massachusetts, as well as in the Northeast, is sold in designated marketing orders. Under such arrangements, the U.S. Government guarantees a base price that is guided by costs of production. Therefore, within the dairy industry the costs of production are somewhat mitigated, which explains the higher prices received by Massachusetts. At present, there is a large national surplus of dairy products which has recently resulted in a move to lower dairy support prices. If such an occurrence does take place, it is likely that many marginal dairy farmers (those whose costs of production, both variable and fixed, are close to revenues received) may be "squeezed" to the point of going out of business. If this occurs, it is likely that the loss of dairy farms will not only continue, but may, in fact, increase.

Broilers: As noted in Chapter III, the production of broilers in Massachusetts peaked in 1950 and has declined rapidly since. No data are reported by USDA on broilers in the State after 1972. The major reason for the demise of the broiler industry in Massachusetts is that, nationwide, the need to provide a steady supply of chickens of consistently high quality to meet consumer demands had led to vertical integration of the broiler industry, or the linking together of successive stages of production and marketing through ownership or contracting. Most broiler firms now consist of a hatchery, feed mill, processing plant, and distribution facilities, and the growing of the birds is done on a contractual basis. In addition, the industry has adopted many technological innovations, and is now highly capital intensive, exhibiting significant economies of scale. As a result, the production of broilers has become highly concentrated, both regionally and in terms of ownership. In 1969, more than 95 percent of production was concentrated in ten States. Most of these States are located in the South where labor costs are relatively low, the climate is mild, and access to feed supplies is good (30, 33, 35, 48). Massachusetts farmers are no longer able to compete with such an industry.

Eggs: Production of eggs has also declined in Massachusetts, dropping more than 50 percent since 1959 (Table 25). Pennsylvania, the largest producer of eggs

Table 25--Number of Eggs Produced in Massachusetts
and Competing States, 1959-1978

	:	:	:	:	
	:	Massachusetts	California	Georgia	Pennsylvania
	:	- <u>millions</u> -			
	:				
1978	:	341	8,412	5,662	3,436
1974	:	541	8,467	5,284	3,299
1969	:	524	8,380	5,426	3,316
1964	:	607	7,801	3,299	3,143
1959	:	739	5,236	1,585	3,625
	:				
	:	Index (1959=100)			
	:				
1978	:	46	161	357	95
1974	:	73	162	333	91
1969	:	71	160	342	91
1964	:	82	149	208	87
1959	:	100	100	100	100

Source: USDA, Agricultural Statistics

in the Northeast, has also shown a decline. At the same time, the nation's two largest egg producers, California and Georgia, have experienced substantial growth in output; especially Georgia, where production has more than tripled since 1959. Changes in the structure and regional distribution of the egg industry in the past 20 years have paralleled to some extent trends in the broiler industry, with production now starting to become vertically integrated and more heavily concentrated in certain States, notably those in the South (30). Opportunities still exist, however, for on-farm processing and direct marketing to supermarkets in Massachusetts. Commercial feed prices remain competitive in the State (although farmers grow virtually none of their own grain), and the prices received by Massachusetts farmers are, on the average, higher than in the other three States being compared.

CHAPTER VII

THE EFFECTS OF URBANIZATION ON MASSACHUSETTS AGRICULTURE

CHAPTER SUMMARY

About 9,000 acres of cropland and pastureland were converted to urban uses each year between 1967 to 1977. Prime farmland is more susceptible to development than non-prime land. More active farmland, however, was simply idled between 1951 and 1971 than was directly converted to urban use. The Massachusetts Agricultural Water Quality Study examined 177 agricultural towns in the State and found a decrease of 107,479 acres (decrease of 27.3 percent) of agricultural land between 1971-72 and 1980. While the abandonment of active farmland may be brought about by economic conditions inherent in the farming sector, it can also be encouraged by the spillover or secondary effects of urbanization. These spillover effects include: nuisance lawsuits brought by nonfarm residents against farmers; vandalism of farm property; exercise of the power of eminent domain by State and local governments to acquire farmland for public purposes; rising property taxes, loss of farm infrastructure; land speculation; and a sense of impermanence among farmers. Statistical analyses of town-level data on farmland abandonment show that rates of idling are highly correlated with population density in the more urbanized parts of the State. In the five counties surrounding Boston, nearly half of the variation in rates of farmland abandonment can be explained by population density.

The Conversion of Farmland to Urban Uses

The loss of farmland due to structural changes in the farming industry, and the relative competitive position of Massachusetts farmers with those in other States has been discussed in some detail in the preceding chapters. This chapter focuses on the specific role which urbanization, and its associated indirect (or spillover) effects may play in the loss of agricultural land. The National Agricultural Lands Study estimates that an average of 30,000 acres of active and potential farmland in Massachusetts were converted to urban and related uses each year between 1967 and 1977 (27). About one-third of this land was cropland or pastureland prior to conversion, and the remainder was forestland with agricultural potential. The loss of this land has been primarily a function of urban demand, for it has negatively impacted upon the viability of agriculture in the State. Developers are typically able to outbid farmers, even successful farmers, for parcels which come on the market, since the return on non-agricultural development far exceeds the return on agricultural investments. Of course, those farms which are experiencing economic problems are considerably more susceptible to development since they are more likely to be put up for sale. Hence, urbanization may claim a disproportionate amount of land from certain (less viable) enterprise groups, thereby changing the mix of farm enterprises over time. But, the viability of agriculture, in and of itself, does not appreciably affect the overall level of population and economic growth in the State, and it is the growth of population and the non-agricultural sector which ultimately determines the amount of land which is developed (unless growth control measures are instituted).

An important consideration, however, is the extent to which prime versus nonprime land is lost to urbanization. NALS estimates that approximately one-third of the land converted between 1967 and 1977 (about 10,000 acres per year)

was prime farmland before conversion, although only 14 percent of all the remaining undeveloped land in the State (448,000 acres) is classified as prime. In a sample of 82 towns in Massachusetts, recently surveyed by the Soil Conservation Service, urban land uses account for an average of 14.5 percent of the total land area of each town, while 23.7 percent of the prime land is now in urban use. In 70 out of 82 towns, the percent of prime land which has been developed is higher than the proportion of all land developed. Thus, prime farmland, which is relatively flat and well drained, is clearly more vulnerable to urbanization than land which is not as well suited to agricultural production.

The Idling of Farmland

Based on a detailed analysis of land use changes in twenty-six Massachusetts towns ^{18/}, Foster and MacConnell (¹⁴) estimate that between 1951 and 1971, the average annual loss of land from active agriculture was 13,300 acres (Table 26). Forty percent of this land (5,300 acres/year) was converted to nonfarm (urban) uses, but the bulk of it was simply idled and was classified in 1971 as either "abandoned and unused" (4,200 acres/year) or "forest" (2,700 acres/year). ^{19/} Another 1,100 acres were converted each year to "other" uses, i.e., recreation, mining, waste disposal, or wetlands. The idling of farmland has undoubtedly occurred in part because of an increasingly unfavorable economic climate for certain agricultural enterprises throughout the State. The idling of productive land, however, may in some cases be encouraged indirectly by urban development. When nonfarming households take up residence in agricultural areas, their presence often gives rise to political and economic conditions which are detrimental to farming. Such indirect and unintended effects of development are commonly termed external effects, or, more simply, "externalities" by economists. The negative externalities associated with urbanization may precipitate or hasten the decline of agriculture, thereby resulting in a loss of actively farmed land beyond that which is directly converted to urban uses.

Researchers have documented several types of negative externalities which frequently accompany the spread of development in agricultural areas. The most commonly cited problems are as follows:

- Lawsuits may be brought against farmers by nearby residents under the common law of nuisance, or local ordinances may be enacted, to protect residents against the noxious effects of
- . routine farming operations, such as odors and flies caused by manure spreading, noise and slow-moving traffic generated by tractors and other farm machinery, and the release of toxic substances which may accompany the application of pesticides (³, ⁴, ¹¹, ³², ⁴¹).
- . Nearby residents and pets may willfully or accidentally damage or destroy farm property. Some of the common complaints

^{18/} The land use data were gleaned from aerial photographs taken in 1951 and 1971 (See MacConnell, 1973-75).

^{19/} Abandoned farmland is classified as "forest" if it has a tree cover of 30 percent or more; otherwise, it is considered "abandoned and unused" land.

Table 26--Estimated Average Annual Loss of Land from Production Agriculture
to Other Specified Uses in Massachusetts, 1951 to 1971 (1)

Agricultural land use in 1951/52	Land Use in 1971/72				Total acres lost from agricultural use
	Abandoned and unused	Urban	Forest	Other (2)	
					- acres lost per year -
Tilled	1,500	2,800	800	800	5,900
Nursery	*	*	*	*	
Orchard	200	200	100	*	500
Total of above intensive uses	1,700	3,000	900	800	6,400
Pasture	2,500	2,300	1,800	300	6,900
Total of all above agricultural uses	4,200	5,300	2,700	1,100	13,300

* Less than 50 acres

(1) Based on sample of 26 towns.

(2) Primarily recreation but also includes mining, waste disposal, and wetlands.

Source: Foster, John H. and William MacConnell, "Agricultural Land Use Change in Massachusetts, 1951-1971," January, 1977

of farmers are: that refuse and litter is often discarded in farming areas where it may interfere with machinery operations or be ingested by farm animals; produce is frequently stolen and sometimes vandalized; and livestock may become prey to dogs allowed to roam loose (3, 4, 11, 41).

- Local and State governments may invoke the power of eminent domain to purchase farmland for recreation facilities, roads, public utilities, reservoirs, etc., thereby taking land out of production and sometimes splitting parcels into economically inefficient sizes (3, 4, 11).

- The farmer's property tax typically rises with the spread of suburban development, due to increasing community demands for public services and facilities such as schools, roads, and police and fire protection (3, 4, 11, 23).

- As the agricultural sector declines due to the growing demand for land by nonfarm interests, the local farming infrastructure (e.g., farm equipment, and supply dealers, slaughterhouses, food processing plants, etc.) may start to disappear, making farming even less viable (see discussion of critical mass in Chapter VIII) (3, 4, 11, 17, 23).

- Rising land values and speculation on the urban fringe may induce farmers to sell land before it is actually needed for development, and farmland prices may become prohibitively expensive for young farmers trying to get started (3, 4, 11, 17).

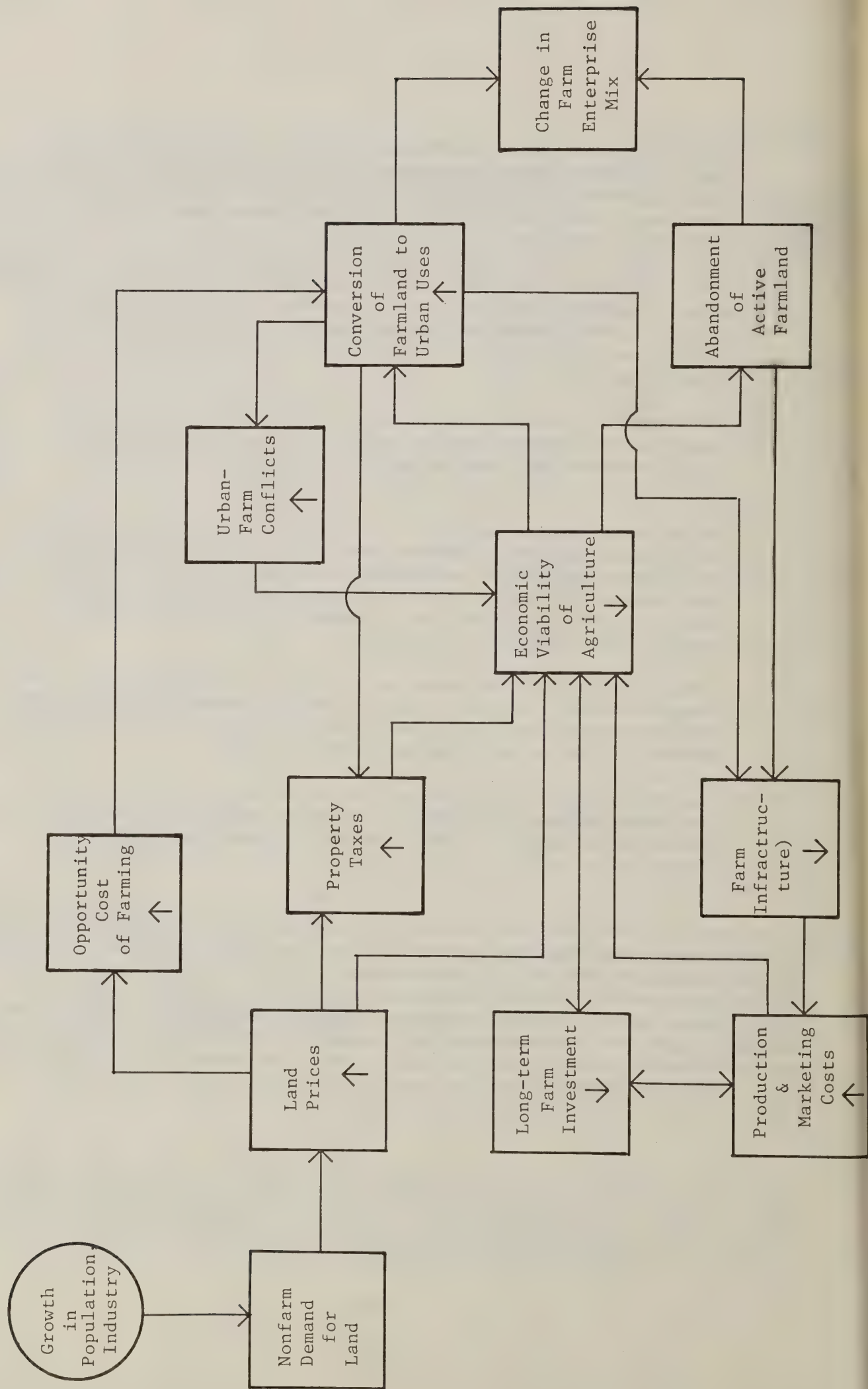
- A general sense of impermanence among farmers (sometimes called the "impermanence syndrome"), may result in the postponement of capital investments, a deterioration in farm management practices, and a reluctance of children to take over family farms (4, 9).

The direct and indirect effects of urban growth are summarized in Figure 7. It can be seen that the major impetus to agricultural decline is the increase in land prices, which not only represents a barrier to entry and expansion in the farming sector, but also raises the opportunity cost of farming. ^{20/} All of these factors tend to reduce the economic viability of agriculture, thereby leading to the conversion of farmland to urban uses or the abandonment of farmland. Since certain farm enterprises are more susceptible to these forces because of their particular set of production inputs, the enterprise mix will also change over time.

^{20/} The opportunity cost of farming is the implicit cost to the farmer of keeping his land in agriculture, which has a relatively low return per acre, rather than selling it at a high price and investing the capital elsewhere. Therefore, as the market price of land rises, or interest rates rise relative to farming profits, the opportunity cost of farming increases.

Figure 7

Direct and Indirect Effects of Urban Growth
on Agriculture in Massachusetts



Once the process of agricultural decline has begun, it may be difficult to arrest because of the several positive feedback loops which occur in such instances. For example, an initial decline in farmland, caused by either conversion or abandonment, may then lead to a decline in farm infrastructure, which in turn increases production and marketing costs, which reduces the economic viability of agriculture, which leads to conversion or abandonment, and so on. Another example is the conversion of farmland to urban uses, which leads to urban-rural conflicts, which reduces the viability of farming, which results in the additional conversion of farmland to urban uses, etc., etc.

The major question, however, is to what extent can these urban externalities be held accountable for the idling of active farmland? Most of the literature dealing with the indirect effects of development on farming is primarily anecdotal in nature, limited to citing several specific examples of farm-non-farm conflicts. One statistical study which attempted to assess the importance of urbanization externalities in promoting the idling of farmland in the Philadelphia Metropolitan area was conducted by Berry (3) who statistically estimated the correlation on the rates of farmland idling with population density, percentage of prime farmland, or both. ^{21/} He found that in minor civil divisions (MCD's) with low population density (less than one person per acre), the rate of idling was strongly associated with soil quality, i.e., townships containing less prime land exhibited higher rates of abandonment. In the moderate and high density MCD's, the effects of soil quality were not consistent. Abandonment rates, were, however, significantly higher in moderate MCD's (between one and four persons per acre) than in low density MCD's. This finding suggests that externalities associated with residential land use may exert some influence on the farmer's decision whether or not to continue farming. The relation between idling and population density, however, did not hold when comparing moderate and high MCD's.

As part of this study, the idling of farmland in 327 Massachusetts towns is analyzed in relation to several population and land use variables, using data collected from aerial photographs in 1971 (21). The importance of the indirect effects of urbanization on farming in Massachusetts is then assessed. Before turning to the statistical analysis of the town data, however, the general spatial patterns of population and agriculture in the State are described using aggregate county level data.

The Spatial Distribution of Population and Farms in the State

Significant spatial variations in the distribution of farms and residences exist in Massachusetts, and, therefore, one would expect that the problems which Massachusetts farmers encounter differ in scope and degree from one place to another. In general, the eastern half of the State is more heavily populated, with by far the highest density occurring in Suffolk County (which contains Boston), followed by the surrounding counties of Essex, Middlesex, and Norfolk (Figure 7). Bristol and Plymouth Counties, located to the south of the Boston metropolitan area, also exhibit relatively high densities, as does Hampden County which contains the urban concentration of the Springfield-Holyoke-Chicopee metropolitan area. The remaining counties all have less than 500 persons per square

^{21/} A. Kruskal-Wallis one-way analysis of variance was performed.

mile on the average, with Franklin and Berkshire Counties in the northwestern and western parts of the State, respectfully, being the most rural in character (Dukes and Nantucket also have few permanent residents, although these island counties are basically resort areas). Barnstable County encompasses Cape Cod and the major form of agriculture is cranberry production in bogs which are not suitable for other than wetland uses. Since eastern Massachusetts is generally more urbanized than western Massachusetts, one would expect that urban-rural conflicts are more pronounced in this region.

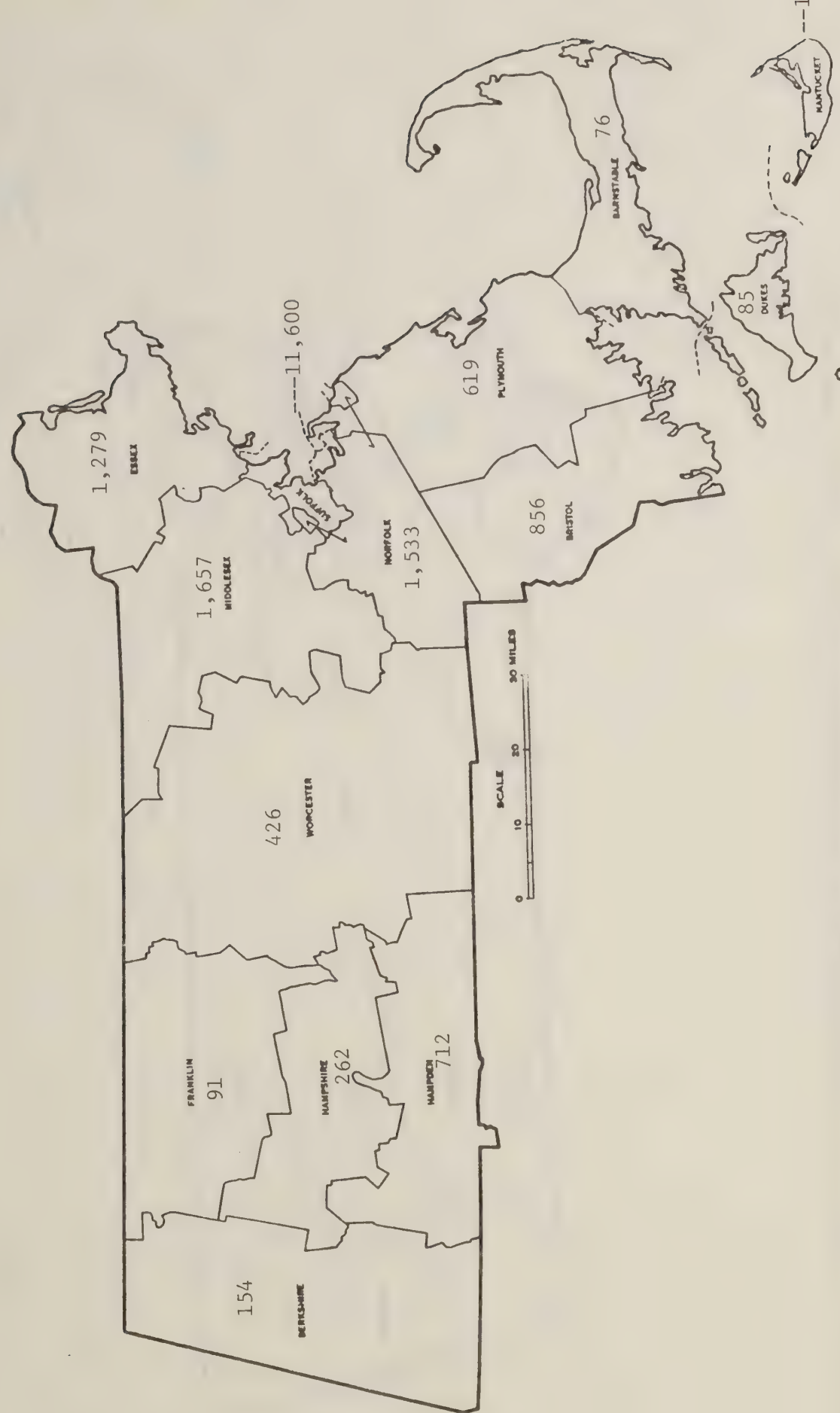
Rates of growth in population and housing over the decade 1970-80 do not tend to correlate with density (Figures 8 and 9). Overall, the State's population grew only marginally (less than one percent), although the number of housing units increased by 16.7 percent, representing over 316,000 new units. Housing continues to spread even though population growth has virtually stopped because the average size of households dropped dramatically during the 1970's. Many more single persons, as well as childless couples, now live as separate households, particularly in urban areas. Thus, the demand for housing relative to population growth continues to grow, which results in increased pressure on farmland.

Middlesex, Norfolk, and Hampden Counties, as well as rural Berkshire County, all declined in total numbers of residents. Barnstable, Dukes, and Nantucket grew at the fastest rate, although the total population of these counties is relatively small. In terms of housing units, all counties showed a net increase, with the bulk of the new units built in the eastern half of the State (Middlesex, Plymouth, Worcester, Barnstable, Norfolk, Bristol and Essex Counties). The highest rates of growth, however, were exhibited in the less densely populated counties, notably Nantucket, Barnstable, Dukes, Plymouth, Hampshire, and Franklin. Thus, while urban encroachment into farming areas is still considerably more prevalent in the densely populated eastern half of the State, many areas outside the Boston Metropolitan area are growing proportionately faster.

Farmland is scattered throughout the State, although the largest concentrations are found in Franklin and Hampshire Counties (which contain the fertile lands of the Connecticut River Valley) as well as in Plymouth and Worcester Counties (Figure 10). Farming in the western half of the State is dominated by dairying, followed by livestock, field crop production, and fruit and vegetables. In the east, fruit, vegetable and nursery/greenhouse production dominates. Fruits, vegetables, and horticultural specialties yield a high return on land, and the value of sales per acre of farmland in the eastern part of the State is therefore generally higher than in the western half (Figure 11).

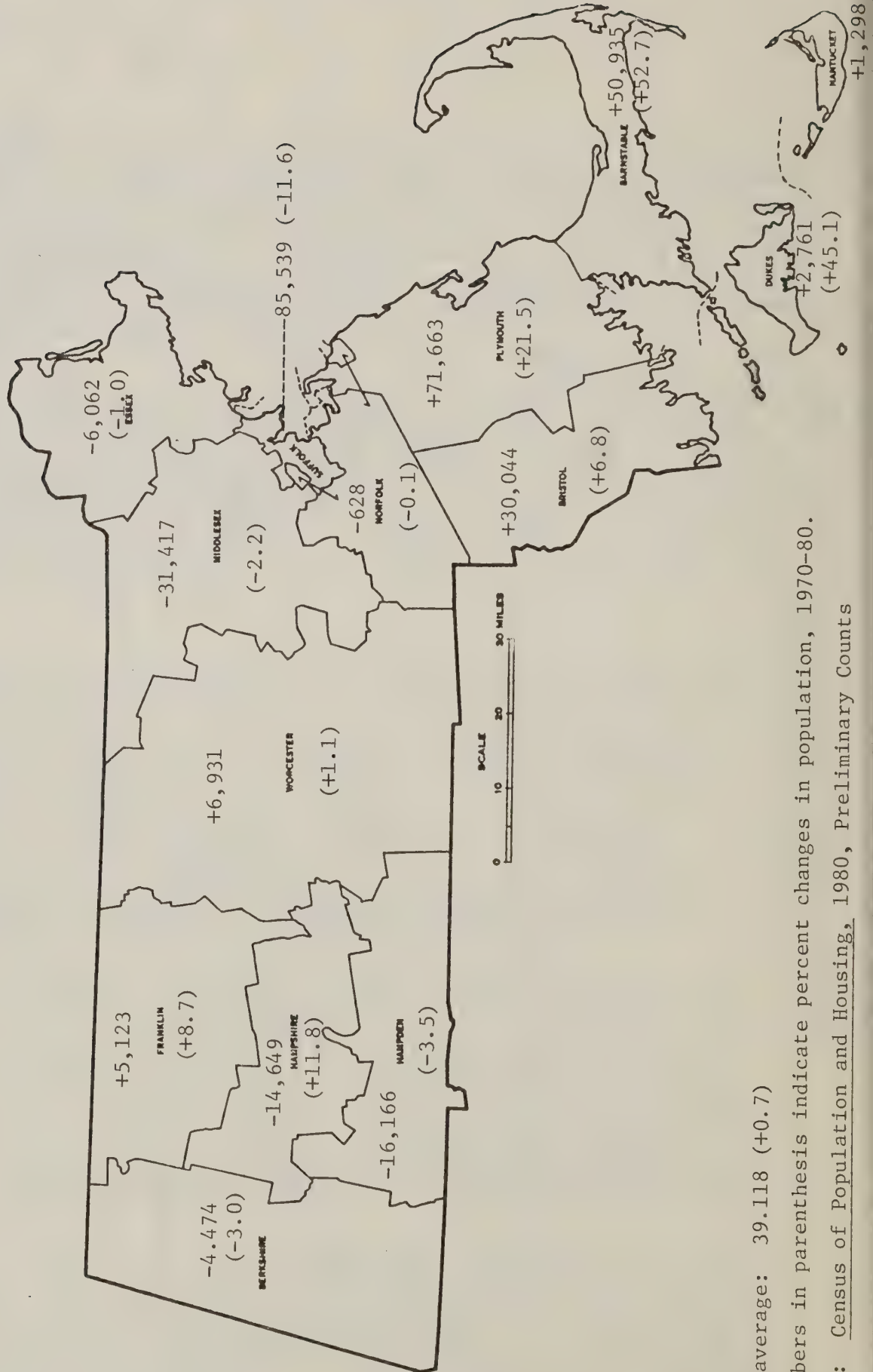
One of the reasons that farmland is used more intensively in the more highly urbanized areas of the State is that high-value crops tend to be produced near market areas. Also, land values are higher in the heavily populated counties (Figure 12), and farms tend to be smaller in acreage (Figure 13). In order to realize an adequate return on limited acreages of high-value land, farmers must produce those commodities which yield a high value of sales per acre.

Figure 8
 Population Density, Massachusetts, By County, 1980
 (persons per square mile)



State average: 731
 Source: Census of Population and Housing, 1980, Preliminary Counts

Figure 9
Population Change, Massachusetts, By County, 1970-80, Numbers^{1/}

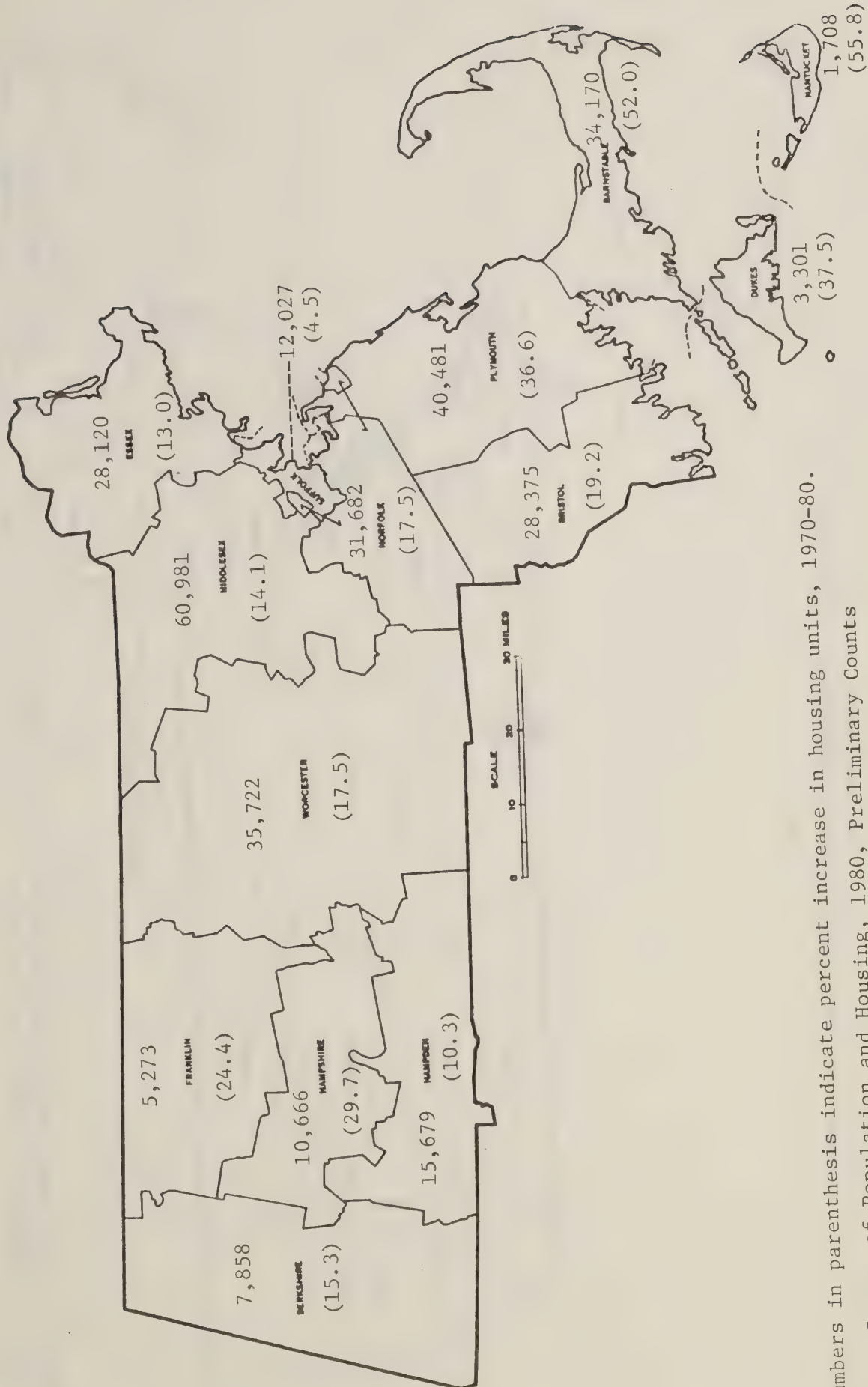


State average: 39,118 (+0.7)

^{1/} Numbers in parenthesis indicate percent changes in population, 1970-80.

Source: Census of Population and Housing, 1980, Preliminary Counts

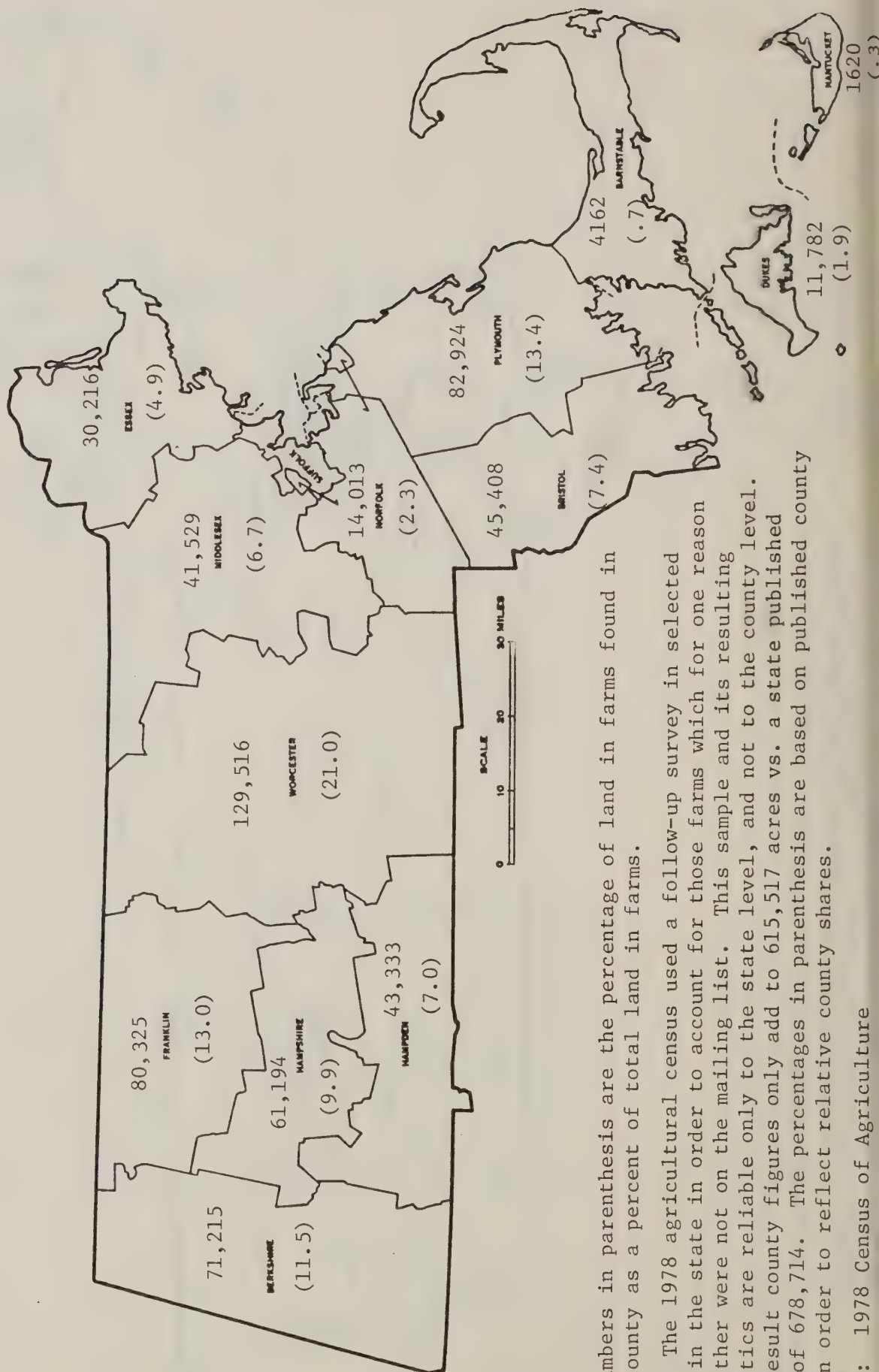
Figure 10
 Number of Additional Housing Units, By County, 1970-80,^{1/}



^{1/} Numbers in parenthesis indicate percent increase in housing units, 1970-80.

Source: Census of Population and Housing, 1980, Preliminary Counts

Figure 11
Land in Farms, Massachusetts, By County, 1978, Acres^{1/}

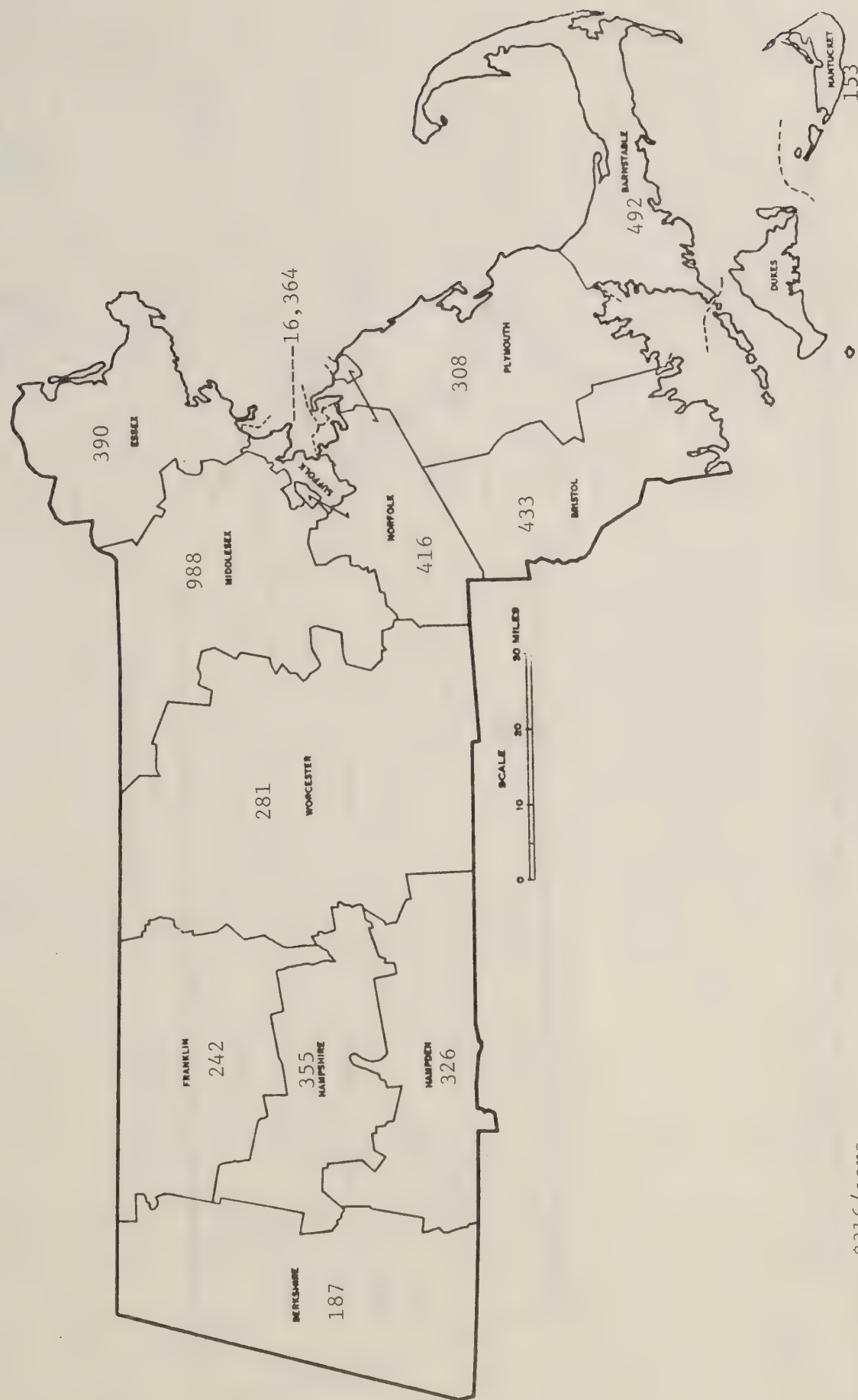


1/ Numbers in parenthesis are the percentage of land in farms found in each county as a percent of total land in farms.

Note: The 1978 agricultural census used a follow-up survey in selected areas in the state in order to account for those farms which for one reason or another were not on the mailing list. This sample and its resulting statistics are reliable only to the state level, and not to the county level. As a result county figures only add to 615,517 acres vs. a state published total of 678,714. The percentages in parenthesis are based on published county data in order to reflect relative county shares.

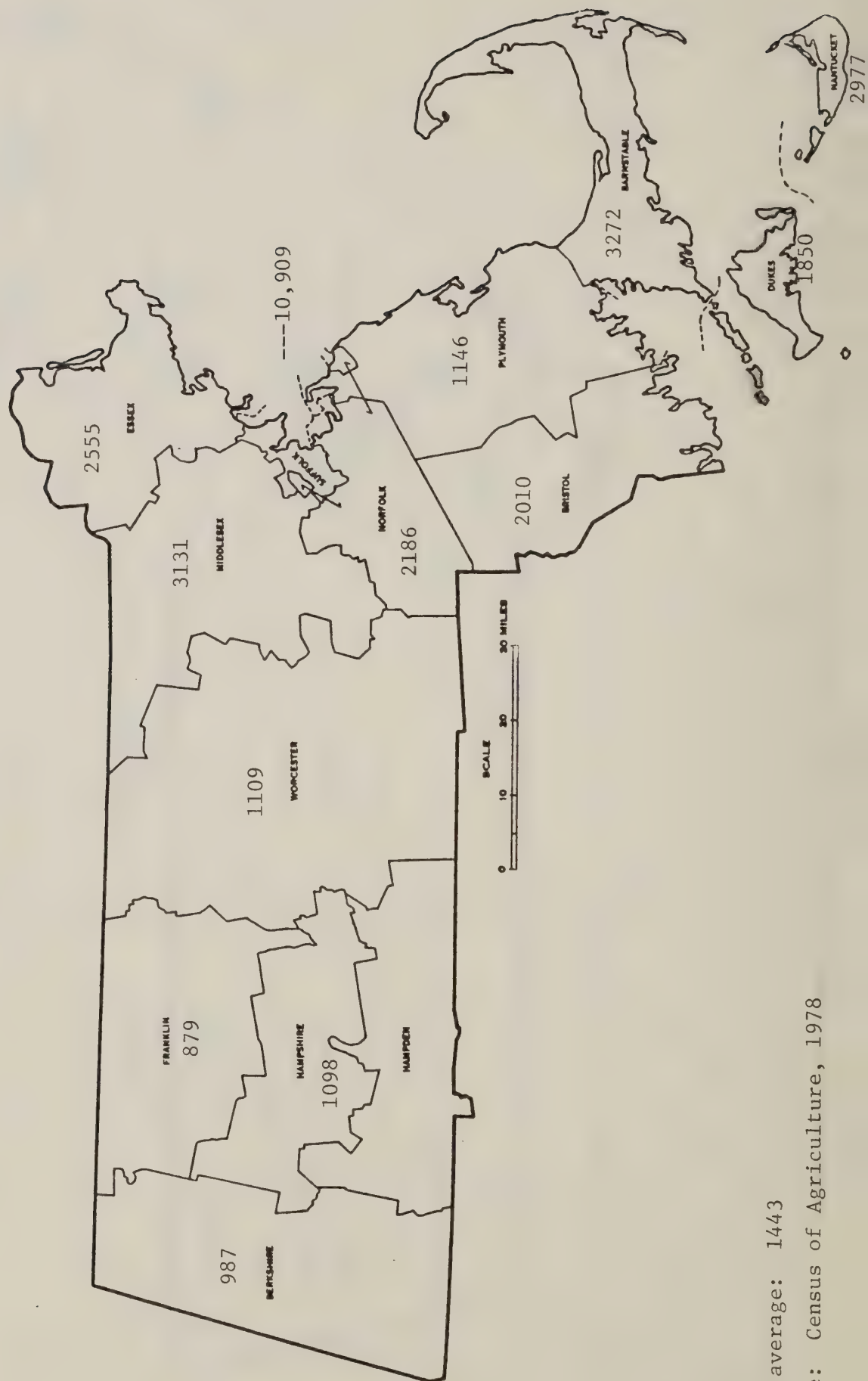
Source: 1978 Census of Agriculture

Figure 12
 Value of Farm Sales per Acre, of Total Land in Farms, Massachusetts, By County, 1978



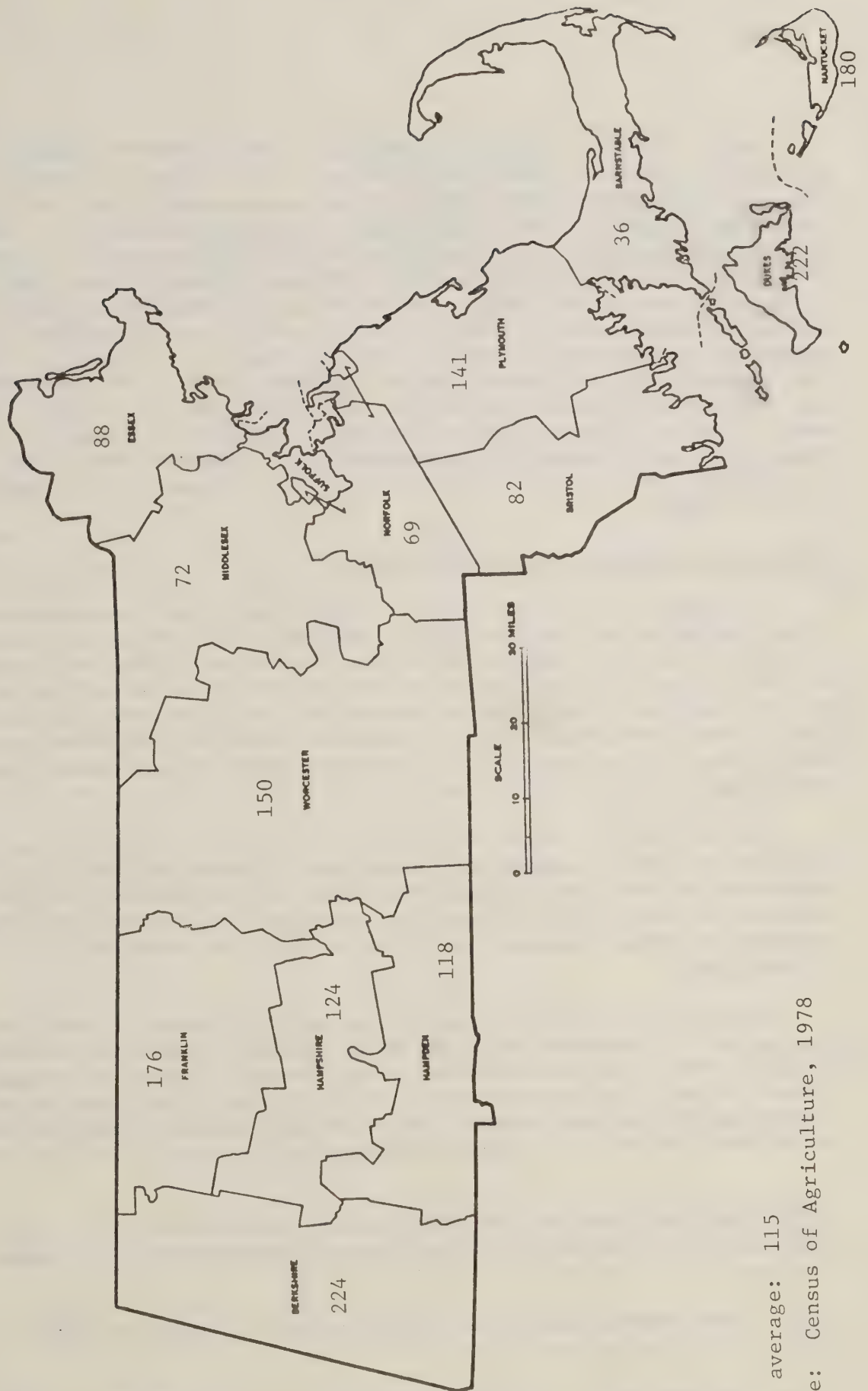
State average: \$316/acre
 Source: Census of Agriculture, 1978

Figure 13
Average Value of Land and Buildings per Acre of Total Land in Farms, Massachusetts,
By County, 1978



State average: 1443
Source: Census of Agriculture, 1978

Figure 14
Average Size of Farms, Massachusetts, By County, Acres, 1978



State average: 115
Source: Census of Agriculture, 1978

Another effect of high land prices is that farmers trying to become established or wishing to expand their operations may find the cost of acquiring land prohibitive, especially when agricultural returns per acre of land are considered. The high land prices in heavily populated areas are due largely to competing nonfarm demands for the land. This is one of the most pervasive of the spillover effects of urbanization on farming. Because of the barrier to entry into the farming business which high land prices create, one might expect the average age of farmers to be higher in urban counties than in rural counties, and that fewer farmers are full owners of their farms in urban counties. However, the data for Massachusetts do not support these hypotheses, as no consistent trends are exhibited (Table 27). The percentage of farmers reporting farming as their principal occupation is, however, relatively higher in the less densely populated counties (Berkshire, Franklin, Hampshire, and Barnstable), suggesting that farming is more viable as a single source of income in rural counties (or possibly, that fewer nonfarm employment opportunities are available).

Statistical Analysis of Farmland Abandonment

In order to test empirically the hypothesis that urban externalities have promoted the idling of farmland in Massachusetts, the extent of farmland abandonment in each of the Massachusetts towns was determined. Detailed land use data for each of the 351 towns in the Commonwealth collected by MacConnell (21), have been employed for this purpose. The land use categories are quite specific; parcels are divided among eleven categories of agriculture and open land, forty categories of forestland, eleven types of wetlands, five categories of mining and waste disposal areas, and twenty-two classes of urban land.

To estimate the amount of farmland idled in the decade prior to 1971 ^{22/}, acreages for three categories of open land - unused tillable, abandoned field, and abandoned orchard - were summed for each town. Statewide, 210,791 acres fell into these three categories, while active farmland totalled 398,787 acres. The largest acreages of idled farmland were found in Franklin, Worcester, and Berkshire Counties (Figure 14).

One-way analysis of variance tests were performed on the town data ^{23/}, using the percent of farmland which was idled (idled farmland/idled + active farmland) in each town as the dependent variable. The initial set of independent variables tested included population density in 1970, population growth from 1960 to 1970 (expressed in absolute numbers and as rates), percent urban land in 1971, acreage of active farmland in 1971 and percent prime farmland. ^{24/} The latter two variables

^{22/} The time frame of ten years is only approximate; it is assumed that farmland abandoned more than ten years would have begun to revert to forest, and hence would be classified as such.

^{23/} Towns with little or no agricultural land were eliminated from the sample, leaving 327 observations.

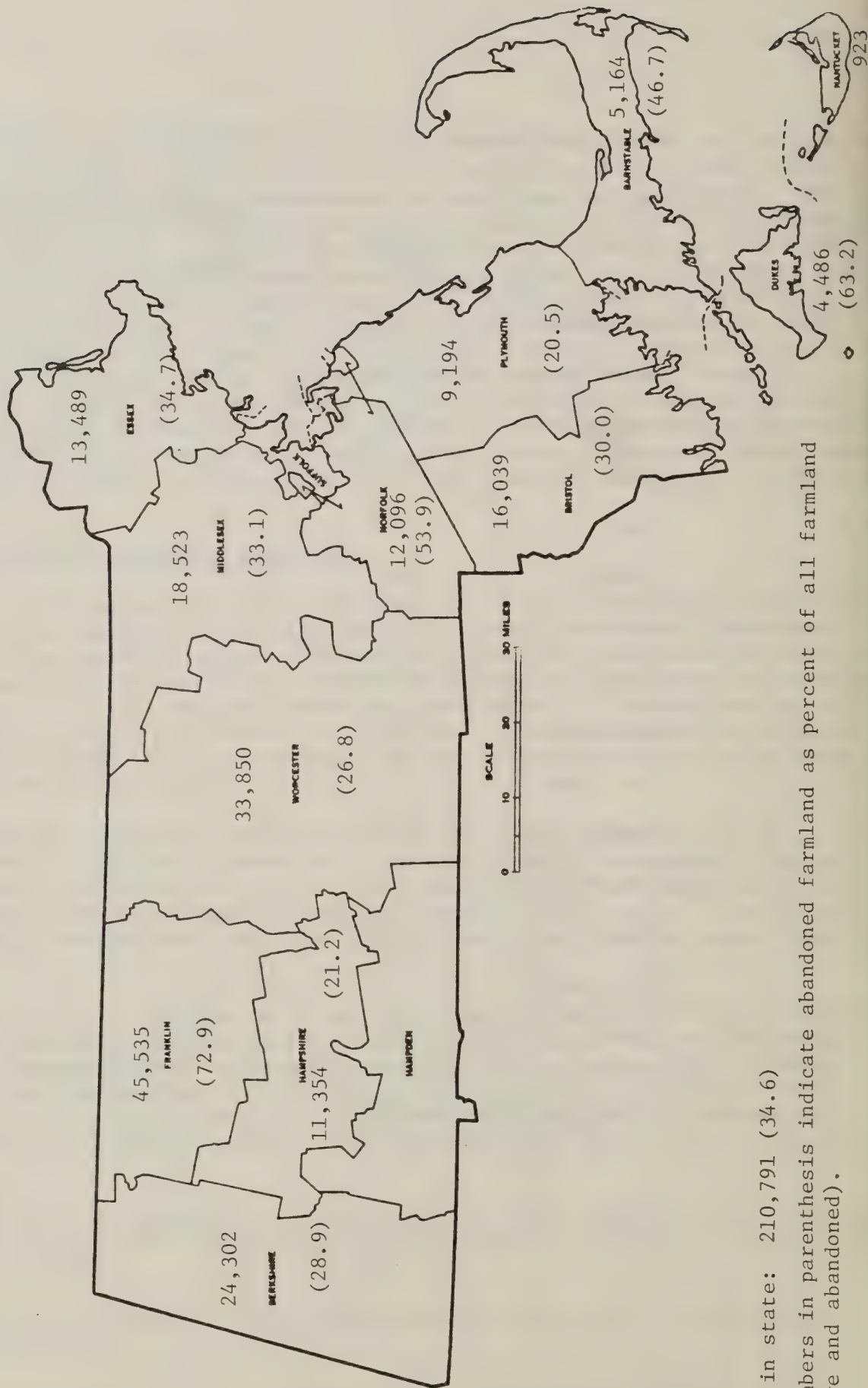
^{24/} The population data were taken from the 1970 Census of Population, percent urban land and acreage of active farmland were calculated using MacConnell's land use data, and prime farmland data were obtained from the Soil Conservation Service for a subset of 82 towns.

Table 27--Characteristics of Farm Operators, by County, 1978

County	Average Age	Percent Full Owners	Percent Reporting farming as principal occupation
Barnstable	54.0	75	63
Berkshire	52.7	56	65
Bristol	51.7	60	57
Dukes	55.5	64	43
Essex	51.5	68	58
Franklin	52.0	47	62
Hampden	53.9	65	56
Hampshire	53.9	58	60
Middlesex	51.7	68	57
Nantucket	50.7	56	44
Norfolk	53.9	72	52
Plymouth	53.0	82	56
Suffolk	51.0	80	40
Worcester	51.8	61	56
TOTAL	51.9	65	52

Source: 1978 Census of Agriculture

Figure 15
 Idled Farmland, Massachusetts, By County, Acres, 1961-71



Total in state: 210,791 (34.6)

1/ Numbers in parenthesis indicate abandoned farmland as percent of all farmland (active and abandoned).

were included to test whether towns with extensive agriculture and/or highly productive soils tend to show lower rates of abandonment.

The analysis of variance tests using population density, percent urban land, and acres of active farmland yield statistically significant results (Table 28). Population density and percent urban land both measure essentially the same thing - the extent of urbanization. Rates of farmland idling are significantly higher in heavily populated towns; however, this relationship does not hold for towns in the low density categories (less than 1,000 persons per square mile or less than 20 percent urban land).

A consistent pattern of abandonment is exhibited when comparing categories of towns according to the amount of actively farmed land. Those towns which contain extensive areas of active agriculture have much lower rates of idling. This finding suggests that agriculture is more viable in heavily farmed areas, perhaps due to "critical mass" considerations (Chapter VIII), or because more farms are generally found where the better soils are located. However, idling displays no consistent trend when compared across several categories of percent prime farmland, using the subsample of 82 relatively rural towns. Rates of population growth also were not significantly correlated with farmland abandonment.

Thus, the analysis of variance tests suggest that urban externalities do play a role in hastening the decline of agriculture in relatively densely populated areas. In order to describe more fully the nature and significance of this relationship, stepwise linear regression analysis was employed. Again the dependent variable tested was percent idle farmland, while the independent variables used were either population density or percent urban land, and active farmland. Initially, the entire sample of 327 towns was subjected to analysis. The standardized regression equation ^{25/} resulting from using population density and active farmland as independent variables is as follows:

$$\text{IDLE} = -.53 \text{ ACTIVE} + .24 \text{ POPDENS} \quad R^2 = .42$$

(F = 146.5) (F = 31.4)

where:

$$\text{IDLE} = \frac{\text{Acres of Idled Farmland}}{\text{Total Farmland}}$$

$$\text{ACTIVE} = \text{Acres of Active Farmland}$$

$$\text{POPDENS} = \text{Population Density}$$

The coefficient for ACTIVE is negative, indicating that the rate of idling increases as the amount of active farmland declines. POPDENS is positively correlated with IDLE, as expected. Together, these two independent variables explain

^{25/} A standardized regression coefficient is calculated by setting the variance of each variable equal to one. They are used here to facilitate comparison of variables expressed in dissimilar units.

Table 28--Rates of Farmland Idling, Classified by Population Density,
Percent Urban Land, and Acres of Active Farmland

A.

Rate of Idling Classified by Population Density				
Group	Population Density	Number of Towns	Mean Rate of Idling	Standard Deviation
1	500	208	37.1	22.0
2	501-1000	55	37.2	16.4
3	1001-2000	34	50.0	18.8
4	2000	30	71.0	18.4

All pairs of groups are significantly different at the .01 level except Groups 1 and 2.

B.

Rate of Idling Classified by Percent Urban Land				
Group	Percent Urban land	Number of Towns	Mean Rate of Idling	Standard Deviation
1	10	149	38.8	24.0
2	11-20	55	33.0	14.7
3	21-40	34	45.5	19.5
4	40	30	68.0	19.9

All pairs of groups are significantly different at the .01 level except Groups 1 and 2.

C.

Rate of Idling Classified by Acres in Active Agriculture				
Group	Acres Actively Farmed	Number of Towns	Mean Rate of Idling	Standard Deviation
1	500	113	63.2	21.5
2	501-1500	127	34.7	13.6
3	1501-3000	54	26.6	8.9
4	3000	33	18.7	7.6

All pairs of groups are significantly different at the .01 level except Groups 3 and 4, which are significantly different at the .05 level.

42 percent of the variance in the percentage of idle farmland throughout the State, as indicated by the R . However, ACTIVE is a much stronger predictor than POPDENS; entered into the equation alone, an R of .37 is obtained with ACTIVE, while POPDENS can explain only 16 percent of the variance. A similar result is obtained when URBAN (percent urban land) is substituted for POPDENS. Thus, the presence of non-farm residents may not be as detrimental to agriculture on a Statewide basis as a lack of other operating farms. As pointed out previously, however, the relationship between rates of idling and active farmland may be explained by several factors. The loss of nearby farms may directly hasten the abandonment of the remaining land by creating a demand vacuum for farm-related industry; or else the high rates of idling and low acreages of active land may both be related to a third factor such as poor soils or unfavorable economic conditions. In any case, much of the variation in rates of idling remains unexplained by this model.

In the second stage of the regression analysis, the POPDENS and URBAN variables were tested for a subset of towns consisting of those in the five densely populated counties surrounding Boston; i.e., Essex, Middlesex, Norfolk, Plymouth, and Bristol. The sample was reduced in this way because it is possible that the effects of urban externalities are exhibited only within a limited range of population density; i.e., where urbanization is most prevalent. Large portions of the western half of the State are probably as yet substantially unaffected by nonfarming activities. Removing the mostly rural counties from the analysis still leaves a relatively large sample of 147 towns.

The results of the analyses of these five counties show that population density (or percent urban land) are fairly highly correlated with percent abandoned farmland. Taken alone, the use of population density as the independent variable produced an R of .47, while percent urban land yielded an R of .50. Thus, about fifty percent of the variation in rates of idling in these five counties can be explained by the urbanization variables. Together, POPDENS and ACTIVE yield the following standardized equation:

$$\text{IDLE} = .51 \text{ POPDENS} - .39 \text{ ACTIVE} \quad R^2 = .59$$

(F = 72.4) (F = 43.9)

While less important, ACTIVE remains a significant variable, indicating again that towns with an extensive farming industry have lower rates of idling.

These findings strongly support the contention that urban spillover effects promote agricultural decline, at least within the sphere of influence of a major metropolitan area. Of course, this type of analysis does not explain the exact mechanisms by which high population densities adversely affect farming. Undoubtedly, a combination of factors, especially high land values and property taxes and the associated "impermanence syndrome," contributes to the loss of active farmland in eastern Massachusetts. In the next chapter, the question of whether a decline of farm-related industry has accompanied and accelerated the loss of agricultural land is analyzed in more detail.

CHAPTER VIII

FARM-RELATED INDUSTRIES AND CRITICAL MASS OF AGRICULTURE

CHAPTER SUMMARY

A certain minimum level of farming activity or a "critical mass" of agriculture is needed to support enough farm-related industry to serve agriculture. Historical data for Massachusetts as a whole show that the number of most types of farm-related establishments has declined since 1959, although employment location quotients computed for 1977 indicate that the State is deficient only perhaps in grain milling and wholesaling. Critical mass problems, however, are likely to be localized, arising only in certain areas where agricultural decline has been most severe. Based on the average farm enterprise mix found in Massachusetts in 1978, it is estimated that about 12,750 acres of farmland within a 314 square mile area are needed to provide a sufficient market for a farm supply store; while 57,082 acres in livestock farms are needed within an area of 2,827 square miles (a marketing circle with a radius of approximately 30 miles) to support a feed mill. Of course, these estimates represent the minimum acreage required to support a single establishment; ideally, each farmer should have access to two or more establishments of each type in order to take advantage of competitive pricing. In any case, the agricultural critical mass in Massachusetts is of sufficient size and density to adequately support the agricultural sector.

What is Critical Mass?

In the preceding chapters, it was discovered that throughout Massachusetts, the abandonment of farmland prior to 1971 was generally more prevalent in those towns containing fewer acres of active farmland. One possible explanation for this finding is that a certain minimum amount of agricultural activity, often called a "critical mass" of agriculture, is needed to maintain the economic viability of farming. Critical mass considerations come into play because of the interrelationships between agriculture and farm-related industry, or farm infrastructure as it is frequently termed. Farm infrastructure includes those businesses which supply inputs to farming, such as feed mills, farm supply stores, farm equipment dealers, etc., as well as markets for farm products, such as wholesale dealers and food processing industries. Agriculture and farm-related industries mutually affect each other through a feedback mechanism. For example, if the farming industry declines below a certain threshold (the "critical mass"), farm stores may either be forced out of business or may switch from their traditional farm orientation to selling lawn and garden supplies to non-farm customers. As a result, farmers may have to travel further and perhaps pay more to obtain supplies, and they may find that the quality and variety of necessary inputs have declined. This situation could therefore exacerbate the problem of agricultural decline, as farmers find it increasingly difficult to maintain viable operations.

Farm-Related Industry in Massachusetts

A variety of agriculture-related industries are found in Massachusetts, and the number of establishments in each industry has fluctuated over time (Table 29). On the input side, the number of farm equipment dealers increased steadily until 1974, and then fell slightly. The number of farm supply stores also dropped between 1974 and 1978 (no data available for previous years). Despite the recent loss of some establishments, in 1977 Massachusetts had one farm equipment dealer for every 9,437 acres in farms and a farm supply store for every 5,982 acres; while the U.S. as a whole had only one equipment dealer per 74,390 acres of farmland and one supply store per 57,428 acres (46, 56). It should be noted, however, that average farm size must be considered. In areas where average farm sizes are quite large, say in excess of 500 or 1,000 acres, it is obvious that the number of acres per dealer would obviously increase. In any case, Massachusetts farmers appear to be relatively well serviced by retail and wholesale input suppliers, although no data on average travel time or distance between farms and input dealers are available.

Feed mills have declined steadily in number since 1964, although this decline has been partially offset by increases in output per mill. While feed mills have declined steadily since 1964, the reduction has not had an adverse impact primarily because of economies of scale advantages. Also, the price of laying feed and dairy feed remained relatively stable during the 1970's.

Table 29--Number of Farm-Related Establishments in Massachusetts,
1959-1978

	: 1978	: 1974	: 1969	: 1964	: 1959
	- <u>Number of Firms</u> -				
<u>Farm Input Supplies</u>	:	:	:	:	:
Farm Supply Stores	: 107	131	N/A	N/A	N/A
Farm Equipment Dealers	: 78	84	31	28	22
Feed Mills	: 8	11	17	21	19
Agricultural Chemicals	: N/A	N/A	11	15	17
<u>Food Processing Industries</u>	:	:	:	:	:
Meat Packing	: 21	11	17	23	23
Sausages and other prepared meats	: 44	52	56	65	68
Poultry Processing	: 2	2	6	8	18
Fluid Milk Processing	: 59	76	133	207	291
Canned Fruits & Vegetables	: 14	16	23	24	27
Frozen Fruits & Vegetables	: 2	3	12	14	N/A

N/A - not available

Source: County Business Patterns

All food processing firms have had significant declines in numbers over the 1959-1978 period, except for meat packing plants (most of which are specialty slaughterhouses) which became more numerous during the 1970's. Poultry dressing and fluid milk processing establishments have decreased dramatically, paralleling to some extent the trends exhibited by poultry and dairy farm enterprises. In the case of poultry, the evidence clearly indicates that the loss of processing firms hastened the decline of broiler production in Massachusetts during the 1960's (see discussion in Chapter VI). Since most dairy farmers in Massachusetts, however, are under federal milk marketing orders, and since much of the decline in the number of fluid milk processors has been offset by increases in output per plant, dairy farming has probably not been as directly affected by the loss of processing firms.

Fruit and vegetable processing plants have also declined substantially in number. Prior to World War II, the vegetable processing industry was concentrated in the Northeast and North Central States. But as vegetable production became concentrated in California due to the expansion of vegetable acreage, most new processing plants were built in the Western States. These new plants were generally larger and more efficient than the older facilities in the Northeast, and the longer growing season in California and in the southern States provided processors a cheaper and more consistent supply of higher quality inputs. As a result, many processing plants in the Northeast, including Massachusetts, have been unable to compete, and the industry has become highly concentrated in the West and South. Potential expansions in farm output of fruit and vegetables in Massachusetts may be hindered by the decline of canning and freezing industries.

Location Quotients

One way to assess whether Massachusetts, as a whole, has a dearth of farm-related industry is to calculate a set of employment quotients (Table 30).

Table 30--Location Quotients for Agriculture and Related Industries
in Massachusetts, 1977

Industry Sector	:	Location Quotient
Agriculture	:	.20
Wholesale Industries	:	
Farm Machinery	:	.20
Farm Supplies	:	.21
Grain Dealers	:	.05
Livestock Dealers	:	.17
Food Processing Industries	:	
Meat Products	:	.32
Dairy Products	:	1.05
Preserved Fruits & Vegetable	:	.20
Grain Mill Products	:	.10
Fats and Oils	:	.36
All Food Industries	:	.65

Sources: Census of Manufacturers, 1977; and Census of Wholesale Trade, 1977

Each location quotient is defined as follows:

$$\text{Location quotient for Industry X} = \frac{\frac{\text{State Employment in Industry X}}{\text{Total State Employment}}}{\frac{\text{National Employment in Industry X}}{\text{Total National Employment}}}$$

A location quotient greater than one indicates that the State has a higher than average concentration of employment in industry X, while a quotient of less than one means that the State has relatively few people employed in that industry, compared to the nation as a whole.

To determine if Massachusetts has a deficit amount of farm-related employment, it is necessary only to discern if the location quotients for the related industries are lower than the quotient for the farming sector. Since agriculture is a relatively small industry in the State, its location quotient is only .20. Wholesale farm supply and farm product dealers all have location quotients in the same range, except for grain dealers, with a very low quotient of .05. The scarcity of grain dealers is not surprising, since Massachusetts farmers market almost no grain. Among the food processing industries, which provide a market for agricultural products, again only grain mill products is small compared to the farming sector as a whole. The manufacture of dairy products is a relatively important industry in the State, with a location quotient exceeding one. Thus, except perhaps for grain processors and wholesalers, Massachusetts does not appear to suffer a disproportionate lack of farm infrastructure, despite recent declines in the number of establishments.

Estimation of Critical Mass

While aggregate Statewide data indicate that Massachusetts is not deficient in farm infrastructure, critical mass problems are likely to be rather localized, occurring only in selected areas where farming has declined rapidly or has always been a very minor industry. Unfortunately, published data on farm-related industry are nonexistent at the town level, and only scattered and incomplete at the county level. Thus, empirical analysis cannot easily pinpoint those areas of the State where agricultural viability may be threatened by lack of infrastructure. For planning purposes, however, it is possible to estimate "a priori" the critical mass of agricultural land needed to support various farm-related enterprises. In this section, the critical mass of farming is calculated in relation to a typical farm supply store and feed mill in Massachusetts ^{26/}, based on the average farm enterprise mix in the State in 1978. Coefficients are also presented which will enable the reader to compute critical mass for different size firms and alternative farm enterprise mixes.

^{26/} A feed mill and farm supply store were chosen for analysis due to the availability of data, and because Dhillon and Derr (13), in a previous study, found these to be the limiting factors in determining critical mass for the Northeast.

1. Farm Supply Store

a. Size of Establishment

The first step in determining critical mass for a farm-related establishment is to define the relevant scale of operations. If one wishes to estimate critical mass for a "typical" firm, the mean or median output, or volume of sales, can be used. While the median would probably better describe the "typical" firm, the data needed to calculate the median are difficult to obtain. The mean, on the other hand, can be readily computed using census data. In 1977, the average farm supply store in Massachusetts had a total volume of sales of \$1,099,054, while for the U.S. as a whole, the mean volume of sales was \$957,183. Thus, a sales volume of \$1,000,000 per year is used in this analysis to represent a typical establishment.

Alternatively, one might prefer to estimate the "optimal" size firm, i.e., the volume of sales which produces the highest margin of profit for the store. Determining optimal scale is difficult; however, on the basis of interviews with industry representatives, Dhillon and Derr (13) estimated that \$1,000,000 in sales also represents an efficient scale of operations for a farm supply store.

b. Calculation of Critical Mass

Determining the number of acres of farmland needed to support a farm supply store is fairly straightforward, although the result varies according to the mix of farm enterprises found in a given region or area. In this section, the critical mass of farmland relative to a farm supply store in Massachusetts is computed, using the average mix of enterprise groups found Statewide in 1978. However, the conversion factors presented can be used by interested persons to calculate critical mass for any possible mix of enterprises.

The critical mass conversion factors, for a farm supply store represent the total amount of dollars spent by farmers for major farm supplies (i.e., commercially mixed feed, fertilizer, lime, agricultural chemicals, seeds, etc.) divided by acres of farmland in each enterprise group in 1978. Those enterprise types which use land very intensively (i.e., yield a high output per acre), such as poultry, horticulture, and tobacco, have a high volume of expenditures per acre, while the ratio is much lower for field crops and livestock (Table 31).

The total acreage of farmland needed to support a farm supply store is calculated using the following general equation:

$$V = Q(p_1 C_1 + p_2 C_2 + p_3 C_3 \dots p_n C_n)$$

where:

V = volume of sales per store (dollars)
Q = quantity of farmland required (acres)
P_i = proportion of all farmland in enterprise X
C_i = conversion factor for enterprise X

where i = 1, 2, 3...n

In order to apply to apply this equation one needs to know not only the volume of sales and the conversion factors, but also the proportion of farmland in each enterprise group within the area under study. These proportions should be uniquely determined for each region under study, since the enterprise mix varies greatly from one part of the state to another. ^{27/} For example, if 50 percent of the farmland is in dairy farms, 25 percent in vegetable farms, and 25 percent in fruit farms, the critical mass of farmland needed to support a typical farm supply store would be calculated as follows:

$$1,000,000 = Q (.50) (99.34) + (.25) (63.19) + (.25) (28.55)$$

$$1,000,000 = Q (49.67 + 15.80 + 7.14)$$

$$Q = \frac{1,000,000}{72.61} = 13,772 \text{ acres}$$

Using the 1978 proportions for the State as a whole, a total of 12,758 acres of farmland would be needed to provide a market for the farm supply store (Table 31). Substituting this figure back into the equation provides the break-down of this "critical mass" of land by enterprise group, as shown.

Table 31--Farmland Required to Support a Farm Supply Store in Massachusetts

Enterprise Group	Conversion Factors Expenditures on Farm Supplies per Acre	Acres of Farmland Required, Based on 1978 Statewide Enterprise Mix
Cash Grain	\$ 4.21	48
Tobacco	197.69	65
Other Field Crop	18.03	1,897
Vegetable	63.19	630
Fruit & Nut	28.55	1,643
Nursery/Greenhouse	397.66	309
General Farms, Crop	14.85	418
Livestock	14.95	2,709
Dairy	99.34	4,377
Poultry	966.27	204
Animal Specialty	230.79	261
General Farms, Livestock	19.33	197
Total		12,758

Source: Derived from 1978 Census of Agriculture

^{27/} Data for counties is available in the 1978 Census of Agriculture, Vol. 1, Part 21 (Massachusetts), Table 8, pp. 108-109.

c. Spatial Considerations

Clearly, the farmland which supports a farm supply store need not immediately surround the store in a contiguous agglomeration. Farmers can travel moderate distances to obtain supplies with relatively little cost or inconvenience to them. No information could be found regarding the maximum acceptable travel time or distance from the farm to the store. However, using the conservative estimate of ten miles, the total market area of one store would cover 314 square miles, or over 200,000 acres. Based on the critical mass estimate computed above (12,758 acres of farmland), only 6.3 percent of the land within a radius of ten miles of a store would have to be farmed in order to meet the critical mass requirements. Thus, farming need not constitute a major land use in order to support a retail farm supply dealer, although a higher concentration of farms would probably attract more than one dealer, thereby encouraging competition and benefiting the farmers.

2. Feed Mill

a. Size of Firm

According to the Census of Manufactures, the mean value of sales per feed mill in the U.S. was \$4.26 million in 1977. The average price of 16 percent protein dairy feed in that year was \$140/ton, while poultry (laying) feed cost about \$152/ton (46). Based on this information, the average feed mill produced about 30,423 tons of dairy feed or 28,021 tons of poultry feed. No data on value of sales are available for Massachusetts feed mills; however, in 1978, Massachusetts farmers purchased 219,258 tons of feed, and there were eight feed mills operating in the State. Thus, output per mill was roughly 27,400 tons/year (assuming no purchases or sales outside the State) which is close to the national average.

The literature contains several studies of the "optimal" size for a feed mill. Synthesizing the results of three of these studies, Dhillon and Derr concluded that the optimal output level is at least 60,000 tons/year. Hopkins, et.al. (18) cite a study conducted in New England which found economies of scale up to 90,000 tons annually, while Vosloh (60) asserts that "definite economies of size" are evidenced in the feed milling industry. Thus it appears that most mills in Massachusetts and nationwide are operating at suboptimal capacity. For the current analysis, an average size firm producing 30,000 tons of feed annually will be used to develop a critical mass estimate; however, the reader can insert a different number, such as 60,000 or 90,000 tons, and perform the computations for an "optimal" firm, just as the enterprise mix can also be altered.

b. Calculation of Critical Mass

Since only livestock farmers depend on feed mills, the critical mass of agriculture relative to a typical feed mill includes only livestock enterprises. In this case, critical mass can be expressed both in terms of number of animals and acres of land in livestock farms (see conversion factors shown in Table 32.a.). Using the mix of the four major livestock enterprise groups in Massachusetts in 1978, it is estimated that a feed mill would require 57,082 acres of land in livestock

farms to generate adequate demand (Table 32.b.). Sixty percent of this land would be in dairy farms, with an inventory of over 10,000 dairy cattle and calves. It should again be emphasized, however, that these data are based on the average enterprise mix statewide; each subarea of Massachusetts may have a very different composition of farms. The conversion factors can be readily used in conjunction with alternative land use mixes to generate area-specific critical mass estimates.

c. Spatial Considerations

Vosloh (61) surveyed the feed milling industry and discovered that in 1975, 89 percent of all formula feed in Massachusetts was shipped by company-owned trucks, and the average distance of haul was 37 miles. For the U.S. as a whole, company-owned trucks shipped feed a distance of 30 miles on the average. Even if 30 miles were considered the maximum desirable length of haul, each feed mill would have a market area of 2,827 square miles, or about a third of the entire State of Massachusetts. To meet the critical mass requirements for one feed mill (57,082 acres of land), only 3.2 percent of the market area need be used for livestock farming.

Conclusions

The critical mass estimates presented in this section describe the minimum acreages required to support a single farm supply store or feed mill in Massachusetts, based on the average enterprise mix found in the State. The mass of the agricultural service sector (both input and output) is of sufficient size and density to adequately support the agricultural production sector. Critical mass could be calculated for other types of farm-related industries, such as equipment dealers, fertilizer blending plants, and marketing establishments, if average rates of consumption or production by enterprise type can be calculated. Dhillon and Derr, however, found that in the Northeast, even less farmland was needed to support establishments of these types than a supply store or feed mill. And, when viewed in relation to the potential market area of these firms, the level of farm activity required is quite small. The major problem with this type of analysis is, of course, that ideally a farmer should have access to several establishments of each type, so that competition is fostered such that the best possible prices and quality of goods and services are available. A single establishment within a given market area would constitute a spatial monopoly, which could be detrimental to the local farming industry.

In order to better understand the relationships between agriculture and farm-related industries, and the effects of growth or decline in one sector on the other, more empirical analysis is needed, at a more localized level. The location and output of both farm enterprises and related industries should be mapped over time within a given region, and the feedback effects of agricultural decline should be traced. It would then be possible to determine whether farmers must travel further, on the average, than before to obtain supplies and services, and perhaps whether prices paid and received have been affected. Personal interviews with farmers and proprietors would also undoubtedly be enlightening.

Table 32--Farmland Required to Support a Feed Mill in Massachusetts

a.				
Conversion Factors				
	:	Commercial Feed Consumed	:	Animals Per Acre
Enterprise Group	:	Per Animal & Associated Stock	:	of Farmland
	:		:	
	:	<u>tons</u>		<u>number</u>
	:			
Hogs & Pigs	:	.084		.91
Beef Cattle	:	.265		.16
Dairy Cattle	:	1.709		.32
Poultry	:	.047		135.60
	:			

b. Critical Mass Estimates, Based on 1978 Enterprise Mix			
Enterprise Group	:	Inventory of	:
	:	Animals	:
	:		Farmland
	:		:
	:	<u>number</u>	<u>acres</u>
Hogs & Pigs	:	7,857	8,634
Beef Cattle	:	2,037	12,736
Dairy Cattle	:	10,918	34,121
Poultry	:	215,744 (1)	1,591
	:		57,082
	:		
	:		

(1) Chickens 3 months and older

Source: Derived from 1978 Census of Agriculture

In the meantime, critical mass estimates can be used to determine the minimum amount of farmland needed to sustain the required infrastructure, keeping in mind that the higher the concentration of farms, probably the better the economic health of the farming industry will be.

CHAPTER IX

CONCLUSIONS, FUTURE AGRICULTURAL VIABILITY, AND PROGRAM CONSIDERATIONS

The causes of agricultural decline in Massachusetts have been examined in detail in the preceding chapters. In general, there are two interrelated categories of effects which have adversely impacted upon the State's agriculture:

1. Direct conversion of farmland to urban and related uses, and the commensurate spill-over effects of such conversion which has resulted in much idling of agricultural land. The primary impacts of these direct and indirect effects have been to increase the price and taxes on farmland. Direct development has also provided alternative employment opportunities, which has resulted in an increase in labor wage rates.
2. Economic and institutional forces have reduced the competitiveness of Massachusetts agriculture. These include technological change, expansion of the interstate highway system, and shifts in consumer and export demand. These forces have resulted in higher production costs, a lack of incentive to increase quality of production with commensurate impacts on prices received by Massachusetts farmers, and a decline in capital investment by the State's farmers since returns are lower than in alternative investments.

The conversion of farmland to urban uses had occurred as a direct result of the demand for new housing and industry in the State. Because the rate of return on development inevitably exceeds the return to farming, developers are nearly always able to outbid farmers for land which comes on the market. It is therefore the development potential of land, not its agricultural potential, which determines its market value. In Massachusetts, the capitalized agricultural use value of farmland represents only about five to forty percent of its market value. ^{28/} The other 60 to 95 percent of the value purely reflects the land's development potential. Thus, it is because of the demand for development, and the resulting disparity between the market value and farm use value of agricultural land, that an estimated 9,000 acres of cropland and pastureland were converted to urban uses each year between 1967 and 1977 (27). Farmland which has been lost to non-agricultural development is, on the whole, irretrievable for agricultural purposes.

In addition to causing direct conversion, the spread of development into farming areas promotes the idling of farmland, due to certain spill-over effects of urbanization. Land prices tend to escalate rapidly in developing areas,

^{28/} This is the range of values estimated for parcels of land included under the Agricultural Preservation Restriction Program, 1980 (from the Massachusetts Department of Food and Agriculture).

encouraging land speculation and making it increasingly difficult for farmers to acquire or expand operations. Property taxes may also rise, due to increasing community demands for public services and facilities. Nuisance lawsuits may be brought against farmers by suburban residents, and vandalism of farm property may become a problem. In some areas, the decline of agriculture due to spreading urbanization may lead to a decline in farm-related industry, making farming even less viable. Finally, a general sense of impermanence among farmers may result in the postponement of capital investments, a deterioration in farm management practices, and a reluctance of children to take over family farms. As a result of these factors, farmers may decide to stop farming even before their land is needed for development. About 50 percent of the idling of cropland and pastureland in eastern Massachusetts can be attributed to one or more of these urban spill-over effects.

The second category of factors which have led to agricultural decline encompasses a variety of economic and institutional conditions which have reduced the ability of Massachusetts farmers to compete with those in other regions. Many of these forces are essentially exogenous; that is, they have not originated within the State's farming sector and are for the most part beyond the control of State or local agricultural officials. Yet, because these forces affect different regions in different ways, they have often had dramatic impacts on the agricultural sector in Massachusetts. Three important exogenous forces which have hastened agricultural decline in Massachusetts include: technological change, which has generally favored the large-scale, capital-intensive farms more characteristic of other regions; the expansion of the interstate highway system which has reduced transportation costs to Northeastern markets; and shifts in consumer and export demand, which have resulted in greater demands for grain and broilers and lower demands for dairy products. This has had an adverse effect in Massachusetts since dairying is the largest agricultural enterprise group in the State. All these factors have served to reduce the competitive position of the State's farmers, whose ability to adapt to such changes is constrained by the relatively short growing season, the shortage of prime soils in large contiguous blocks, distance from sources (and costs) of agricultural inputs (especially feed grains) and non-availability of agricultural land due to the high costs of land in the State.

Certain farm enterprises, however, have fared better than others. Fruit, vegetable, other field crops, and other livestock farms all increased their shares of total agricultural output from 1959 to 1978. On the other hand, the dairy and poultry enterprises account for the bulk of the decline in number of farms and land in farms throughout Massachusetts. The loss of dairy farms is of particular importance, since the dairy industry still accounts for over one-third of all land in farms in the State, and nearly 29 percent of all agricultural sales. In part, the loss of land in dairy farms reflects a national trend, but the rate of decline in Massachusetts has exceeded the national rate of loss. Dairy farming appears to be particularly vulnerable to the direct and indirect effects of urbanization. The traditional market orientation of dairying means that many farms have been located directly in the path of suburban development. Dairy farming also requires relatively large amounts of land, and yields a relatively low return per acre,

making this enterprise group particularly vulnerable to escalating land prices and property taxes. A growing number of dairymen in Massachusetts have been forced to rent land in order to maintain viable operations; in 1978, less than one-quarter were full owners of their farms. The effects of the "impermanence syndrome" are also especially severe for the dairy industry, since farmers who are uncertain about the future of their farms are usually unwilling to make or maintain the large capital investment required for successful dairy farming.

Another problem facing dairy farmers in Massachusetts is that almost all the feed consumed by milk cows (and other forms of livestock) in the State is purchased commercially rather than grown on the farm. As a result, expenditures for feed represent a significantly larger share of total revenues in Massachusetts than in the U.S. and most other dairy regions. The acreage of corn for silage in the State has been increasing in recent years, but most feed ingredients will probably continue to be imported from the mid-west.

The distance of Massachusetts from feed grain sources has also been a major factor in promoting the sharp decline of the poultry industry. After 1960, broiler and, to a lesser extent, egg production became highly mechanized, leading to vertical integration, or the linking together of various states of production and marketing through ownership or contracting. These integrated, large-scale firms are mostly located in the Delmarva Peninsula and States further south, because of good access to feed supplies, milder climates and lower cost labor.

To summarize, agricultural decline in Massachusetts has been brought about partly because of the inability of the agricultural sector to compete for common factors of production also demanded by the non-agricultural sectors in the State, and partly because of the inability of dairy and poultry farms to compete with those in other States. Land which has been idled due to urban spill-over effects (or other economic conditions) may eventually be reclaimed, although the decline in the number of farmers and the loss of farm infrastructure may make the future revitalization of agriculture difficult.

Factors Affecting Agricultural Viability

The factors which have had significant effects upon agricultural viability are summarized in the following table:

Table 33--Factors Affecting Agricultural Viability,
Findings and Consequences

<u>Factor</u>	<u>Findings</u>	<u>Consequences</u>
Price of agricultural land	Price of ag land 130% greater than NE average, 229% greater than U.S. average. The capitalized agricultural use value of farmland represents only 5-40 percent of its market value in Massachusetts	Establishes barriers to entry and expansion; results in small average size farms which places constraints on farm income, ability/willingness to invest in and adapt technological improvements. Encourages renting because entering farmers cannot buy and may result in soil deterioration if short-term rentals are the norm. Not conducive to aggressive expansionary development due to uncertainty of tenure.
Farm real estate taxes	High property taxes. \$20 per acre average as compared with the national average of \$3.34 (nearly 600% higher). Mass. farmers pay 6.2 percent of income on property taxes, whereas on national basis, only 3.2% is paid on property taxes.	High farm taxes result in increased operating costs, less after-tax farm income and less of an ability or willingness to invest in capital improvements. High property taxes also serve as constraints to entry and expansion. Property owners who rent will desire production of high income crops (if share cropping) rather than extensive livestock enterprise due to higher returns.
Farm Size	Mass. farms average 115 acres as compared with NE average of 164 and US average of 475 acres. This results from land tenure patterns established during highly labor-intensive agriculture of the late 1600's through 1800's. High land prices, resulting from both ag and non-ag demands for land, have limited potential of farmers to expand size of operation by purchase. Renting is an alternative.	Small farm size results in lowered farm income and less ability to take advantage of economies of scale which have accompanied many technological improvements. Reduces ability and willingness to invest when the economic entity (the farm) is of such size that total production and consequent farm income on a farm-wide basis is constrained. In addition, small farms usually require off-farm income if the farm is to survive.

Factor

Production costs

Cost of production coefficients (ratio of total production costs to gross farm income) and absolute cost per unit of input are higher in Mass. than the US for feed, fertilizer, ag chemicals, petroleum energy products, hired labor, and other expenses (taxes, depreciation, interest, cash rent, insurance, repairs, electricity, water purchases, veterinary services, and other operating expenses).

Prices received for agricultural goods

Mass. farmers, on the whole, receive lower prices than their counterparts elsewhere. Major problem is lack of quality. Some commodities, however, receive higher prices than the U.S. average which is due to market proximity (apples, hay, potatoes), non-market forces (milk) and/or scarcity of product (calves, hogs). Higher prices offset by higher production costs, especially in the dairy and other livestock operations. In addition, given the relatively few agricultural commodities produced and the relatively short growing season, market saturation usually occurs relatively early in the marketing season which has consequential price depressing effects. Lower quality of ag

Consequences

Farmers are price takers because no one farmer purchases enough inputs relative to the total purchased by the ag sector to demand and receive significant discount purchases. As a result, there is little farmers can do except to maximize operation efficiencies. However, some ag enterprise groups, specifically those that use land most extensively (dairy and other livestock) face greater disadvantages in that relative to the US and the NE region, they not only pay higher costs per unit of feed, but also purchase 97 percent of their feed from commercial mixers. Given the high cost of agricultural land, soils and climate, significantly increasing small grain and feed crop production is not feasible. Thus, unless increases in operational efficiency are realized, the dairy enterprise group or other extensive land users will be hard pressed in the future.

Mass. farmers, for the most part, sell directly to consumers primarily through farmer owned and operated roadside stands. While this marketing outlet results in higher prices, the investment costs, time requirements and spoilage usually offset this marketing advantage. Prices received situation is like the "chicken or the egg" dilemma. Prices received could be enhanced if quality of production were increased. However, the lack of processing/wholesaling firms that usually pay higher prices for higher quality goods, results in a lack of incentive to farmers to raise quality. At the same time, processing/wholesaling firms are hesitant to invest in a Massachusetts location because they feel that an adequate quantity of agricultural products meeting accepted quality standards would not be forthcoming. Massachusetts

Factor

Prices received
(cont)

goods also results in lower prices. Lack of processing/wholesaling firms also contributes to the prices received problem.

Wholesaling/
processing
infrastructures

The critical mass analysis showed that, on the whole, there appears to be adequate production input infrastructure (machinery dealers, feed suppliers, etc.) and marketing/processing outlets (dairy processing, roadside markets, etc.). However, there is only one large wholesale market in the State (Chelsea Market), and relatively few processing firms.

Age of farmers

The average age of Massachusetts farmers (51.9 years) is greater than the Northeast and the national average (50.1). The higher average age is a result of new, younger farmers not entering the agricultural sector, or entering at a lower rate.

Consequences

farmers could offset, somewhat, the market saturation problem by adopting improved storage systems (e.g., controlled atmosphere), improved product handling (e.g., cooling of products immediately after picking to extend shelf life), and adopting new production techniques such as greenhouse and/or hydroponics.

Most processing/wholesale firms operate on a multi-tiered pricing system, paying more for high quality products and less for lower quality products. The lack of such agricultural firms results in a lack of economic incentive to farmers to increase quality of products, which results in lower prices received by farmers. An adequate marketing/processing infrastructure by its very nature extends the marketing period of farm products thus countering somewhat, the price depressing effects resulting from market saturation. A third consequence of having an inadequate (in terms of numbers) infrastructure is that there is a lack of competition that results in higher prices farmers have to pay for productive inputs, while receiving lower prices for output. An improved marketing infrastructure would also generate incentives to increase production of agricultural commodities.

Older farmers usually have shorter planning horizons in that they realize that they will not receive the benefits of long-term capital investments, and as a result, have a tendency not to make such investments. As a consequence, the efficiency of the operation decreases which has negative impacts upon farm income. Further, new farmers wishing to enter

agriculture will not be inclined to purchase farms with outmoded equipment. The continuing trend of increasing average age of farmers becomes more significant in that increasing amounts of agricultural land can be expected to be sold. Given the high cost of agricultural land, those farms with relatively low value of output per acre (e.g., dairy, livestock operations) will have a higher probability of being sold to non-agricultural buyers, resulting in a further decrease in agricultural land.

Productive
capabilities
of the land

In terms of yields per acre, Massachusetts farmers are not significantly disadvantaged. However, climate limitations, land tenure arrangements and farm size play a much more significant role than does productive capabilities of the land.

Productive capacity of the land can be enhanced by adopting improved seed varieties that are designed to be used in cooler climates. In addition, converting to types of crops that have higher valued output per acre would make Massachusetts farmers more competitive than they are at present. Capital investments for drainage, irrigation, and conservation measures may be yield-enhancing, but require a long-term commitment to agriculture to recoup the investment.

Consumer
demand

Those enterprise groups which have declined the most are those for which per capita demand has declined, i.e., dairy and livestock farms. Poultry farms, however, have declined because such farms in Massachusetts cannot successfully compete with other poultry regions. Those enterprise groups that have increased sales are those for which consumer demand has increased.

High land prices, shifts in consumer demand, and the decreases expected in dairy price support levels all bode ill for the dairy sector in Massachusetts. The shift toward those enterprise groups that use land most intensively will continue (namely, fruit and vegetable farms). Thus, there will be a shift toward non-livestock type of enterprises.

Future Agricultural Viability

The historical dominance of dairy and poultry farms in the Massachusetts agricultural sector is giving way to those enterprise groups that utilize land more intensively, namely vegetable and fruit operations. Given the inter-regional, highly competitive nature of poultry operations (broilers and layers), Massachusetts farmers simply are unable to compete effectively, primarily because of the large feed cost component. Dairy operations, while still the largest enterprise group (in terms of sales) in the Massachusetts agricultural sector, have been declining rather precipitously and will continue to do so for three major reasons: (1) the requirements of large amounts of land; (2) the high cost and quantity of feed required; and, (3) declining dairy price supports.

Fruit production, namely apples and cranberries, will, in all likelihood, expand as a proportion of total agricultural sales in the State. Cranberries show the largest potential for value of sales increase because of the nationwide marketing strategies of the Ocean Spray Cranberry Cooperative which markets the vast majority of national cranberry production. In addition, the land utilized for cranberry production (bogs) has very few alternative uses (Massachusetts has very strict wetland protection laws), thus the value of such land is priced closer to its agricultural rather than its developmental value. Apple production will also increase primarily because of the adoption of controlled atmospheric storage (apples can be stored for nearly a year in such facilities with minimal decrease in quality). In addition, other agricultural regions which compete for the apple market, namely the State of Washington, export the delicious variety while Massachusetts' apple growers concentrate, for the most part, on the McIntosh apple. Further, the high value of production per acre of apples, together with the fact that most are produced on hilly slopes, minimize, somewhat, demands for such land by the non-agricultural sector. As a result, much of the apple producing land is priced closer to its agricultural value than those operations which require relatively level land (level, highly productive land is usually located in valley bottoms where competition from the non-agricultural sector is the greatest).

Vegetable production, in terms of value, is expected to also increase primarily because there are relatively high returns per acre. However, there are a number of circumstances that will continue to act as constraints to increased production. Given the climate of the area, vegetable farmers have a limited number of crops they can produce and most of the production comes to market in a relatively short span of time. Thus, market saturation occurs and, as a result, creates a price depressing effect. Most vegetables are marketed directly to consumers, through farmer-operated roadside markets, the largest marketing outlet. Time and investment requirements, spoilage, and a limited marketing area combine to limit, somewhat, the potential for expanding vegetable production.

Policy and Program Incentives

The loss of agricultural land in Massachusetts is, in reality, a symptom of a number of economic, institutional and locational factors that have impacted

adversely upon the State's agricultural sector. Obviously, agricultural land would not have "disappeared" at the rate that it has if the farmers working that land could have attained and maintained a standard of living acceptable to them. Thus, program and policy alternatives, if they are to be effective in curbing the decline of, or in maintaining and/or enhancing the viability of the agricultural sector, must be directed toward enhancing the revenue earning power of farmers. Programs that are directed to the cost side of the equation should deal with those cost components over which the State has some control. Such actions, as decreasing taxes, implementing programs that reduce the cost of the land resource, providing lower interest rates, minimizing State actions that may adversely affect agriculture (e.g., forbid the exercise of eminent domain on farms that are viable such as the building of roads through a farm) would lower costs of production to Massachusetts farmers. Programs and policies that are directed toward increasing revenues to the agricultural sector should deal with the enhancement of marketing outlets, increasing the quality of agricultural goods in order to secure higher prices for locally grown products, and providing incentives to further enhance the agricultural processing sector, etc.

Existing Programs

Massachusetts has been at the forefront in developing and implementing policies and programs designed to enhance the agricultural sector. These programs include: (1) the State's policy on Food and Agriculture; (2) differential taxation on agricultural land; (3) the Agricultural Preservation Restriction Program (APR); (4) protecting farmers from nuisance lawsuits; (5) publishing an Executive Order whereby State institutions will not discriminate against commodities of in-state growers without justification; (6) and the recent signing of "A Social Compact" between the Governor and the Massachusetts agricultural community. Each of these actions by the Commonwealth of Massachusetts is designed to ameliorate, somewhat, the costs of producing agricultural goods, or enhancing the revenue gains of farmers, or both. A brief description of these State-induced actions follows:

Differential Assessment: The Farmland Assessment Act (General Laws, Chapter 61A) of 1973 enables farmers in Massachusetts to have their land assessed at farm use value rather than market value. If land under differential assessment is removed from agricultural use, a five-year rollback tax is imposed, as well as a conveyance tax during the first ten years (the conveyance tax starts at ten percent of sale price the first year, then declines one percent each year). Differential assessment is an important component of the State's agricultural preservation program, particularly in urbanizing areas. However, given the disparity between the agricultural value and market value of farmland, the tax penalties are somewhat ineffectual in preventing the conversion to non-agricultural uses.

The Agricultural Preservation Restriction Program: In 1977, the Massachusetts General Court adopted the Agricultural Restriction Preservation (APR) Program, which is designed specifically to deal with the effects of urban

demand for farmland and the resulting high land prices. Under this program, the State purchases the development rights to certain parcels of farmland each year. The value of the development rights is defined as the difference between the market value of the land and its value for agricultural use. Once the development rights have been purchased, the farmer permanently relinquishes his right to build non-farm structures on the land, ^{29/} but all other rights of ownership are retained. In terms of retaining agricultural land, this is a key point in that the restrictions to other than agricultural uses becomes a part of the property deed. Since development potential usually represents anywhere from sixty to ninety-five percent of the total value of the land, removing this value of the land reduces the price of the land considerably. Thus, not only are specific parcels protected from development, but lowered land prices enable younger farmers to purchase farms and become established and existing farmers are able to expand their size of operation. At the same time, however, while the APR program is extremely effective in retaining agricultural land, it is also an expensive undertaking. The State has expended 11 million dollars to date. A minimum of 8 million dollars will be spent in the next two years for the purchase of development rights on an additional 4,000 acres.

The Massachusetts APR program has been in effect since 1977, and so far development rights have been purchased on 6,500 acres, with another 4,000 acres under agreement. The major criterion for selecting parcels has been the imminent threat of development, the idea being that, with limited funds, more land can be saved in the long run by focusing on those parcels which are almost sure to be lost otherwise. Other criteria include soil quality, contribution of local funds, the economic viability of the farming unit, and its relation to surrounding land uses. Towns have also been asked to prioritize agricultural areas within their borders for the purposes of the program. Assembling a critical mass of farmland has thus far not been a major consideration; the land which has been placed under development restrictions is scattered throughout the State, to maximize coverage of the program as well as to direct resources to those farms which have a high potential of being sold for non-agricultural purposes.

The APR program is designed to counteract the adverse effects of urban growth on farming by directly prohibiting the development of specific parcels of land and by reducing the price of this land. The program is costly, however, since most of the value of the land is embedded in the development rights. Since funds are limited, only about 1,000 acres per year have been placed under restriction or agreement since the program has been implemented.

^{29/} The farmer may build residential structures for himself, relatives, or employees, provided that agricultural productivity is not adversely affected and the Agricultural Lands Preservation Committee approves.

While the program certainly has limitations due primarily to low levels of funding (limited funds preclude the development rights purchase on all tracts, there is no guarantee that preventing development on one tract won't simply drive the development to another, equally valuable agricultural tract), and due to the voluntary aspect of the program (the State can choose only among those farms whose owners have submitted applications), the APR program is directed at the major barrier to the maintenance or enhancement of the agricultural sector. In addition, the APR program may provide psychological effects that counter the "impermanence syndrome" and thus existing farmers may resume making the long-term capital investments necessary for the continuance of agriculture in the State.

Protection From Nuisance Lawsuits: In 1979, Chapter III of Massachusetts General Laws (Section 125A) was amended to read "...the odor from the normal maintenance of livestock or the spreading of manure upon agricultural and horticultural lands shall not be deemed to constitute a nuisance." This law benefits farmers who live near suburban residents, who may object to the odors associated with routine farm operations.

Governor's Executive Order, Sept. 6, 1982: The Governor of Massachusetts published an executive order which is designed to increase public institutional purchasing of Massachusetts grown agricultural commodities. The order specifies that the Executive Office of Administration and Finance will work with the Department of Food and Agriculture to overcome some of the marketing constraints faced by Massachusetts growers who would like to sell to in-State institutions. This executive order is a further attempt to increase the marketing outlets available to Massachusetts farmers.

Social Compact: The Social Compact signed by the Massachusetts Governor on September 6, 1982 is a document that specifies the Governor's support for a number of agriculturally related goals which include, but are not limited to, the following subjects: completion of soils mapping; farmland assessment; inheritance tax changes dealing with farmland; Executive Order #193 (deals with limiting State actions that would adversely impact agriculture); continued financial support for the APR program; closer coordination between the Massachusetts Department of Food and Agriculture; expand low-interest financing to agri-business firms through the issuance of "Agri-bonds;" and a pledge to continue to assist in the development of a more viable agricultural support sector.

Agricultural Incentive Areas: It is obvious that the Commonwealth had instituted a large number of policies and programs that were designed to assist the agricultural sector by helping to relieve some of the costs of production (taxes, decrease cost of ag land through the APR program) and by assisting in enlarging marketing outlets available to farmers. In addition, legislation has been proposed that would establish agricultural incentive areas. As envisioned by the State Department of Food and Agriculture, such areas (sometimes referred to as agricultural districts) would be established on a voluntary basis, but once established, the State government would institute additional policies and programs that would encourage the agricultural sector and discourage non-agricultural development.

Other Program Considerations

Limits on Tax Rates: Despite the implementation of differential assessment, farmers in Massachusetts still pay higher property taxes (both on a per acre basis and as a percentage of farm income) than those in most other parts of the Country. To further reduce the burden of taxation, a ceiling could be placed on tax rates, or a limit could be imposed on a percentage that property taxes are to adjusted gross farm income. The State could perhaps reimburse local governments for tax revenues lost under the first alternative, or provide a credit on the farmer's income tax under the second alternative.

Exercise of the Power of Preemption: As noted previously, one of the shortcomings of the existing APR program is that participation is purely voluntary. As a result, the State has no guarantee that the most productive or most imminently threatened farmland in the State is being placed under restriction. This problem could be solved through exercising the power of preemption, whereby the government could substitute itself for anyone who has made a bona fide offer to purchase any farm in the State. The government then places deed restrictions on the use of the land and resells it at agricultural use value. Thus, such a program achieves the same end as the APR program, except that the State can be certain that the parcels purchased are about to be sold to developers or speculators, and it can choose the "best" among all such threatened farms.

Exercise of the power of preemption is already made possible for cities and towns under the Massachusetts differential assessment law (12). If an owner of land under differential assessment intends to sell his land or convert it to nonagricultural use, he must notify his town or city of his intentions. According to the law, "For a period of sixty days subsequent to such notification, said city or town shall have, in the case of intended sale, a first refusal option to meet a bona fide offer to purchase said land, or in the case of intended conversion not involving sale, an option to purchase said land at full and fair market value to be determined by impartial appraisal. 30/" Such powers could perhaps also be extended to the State for the purpose of acquiring development rights under the APR program.

Improve Product Marketing Outlets: 31/ Given the cost relationships in agricultural production in Massachusetts, and recent Federal government policy changes, it is apparent that those enterprise groups that utilize land in a more intensive manner and thereby derive greater levels of revenue per unit of land input, show the greatest potential for continued economic viability. Specifically, fruit and vegetable enterprises show the greatest promise. However, a few key components of their future viability involves the marketing strategies

30/ Massachusetts General Laws, Chapter 61, Section 14.

31/ Much of this discussion is borrowed from Opportunities for Agricultural Development in Massachusetts, prepared by Jonathan Katz under contract to the Community Economic Development Assistance Corporation. Muchael Mazerov edited the Report. Boston, July, 1981.

employed in getting the products to the consumer, and the products that farmers choose to grow. As noted previously, the major marketing constraint facing growers in Massachusetts is that many are unable to supply a large volume of uniformly packed, high quality produce. As a result, the wholesale brokers offer prices that are, on the average, significantly lower than for produce imported from out-of-state firms that meet the volume and quality standards. In addition, because of the relatively short growing season, and the relatively small number of varieties of produce grown, growers usually end up shipping their produce to the wholesale market when the market is saturated. This obviously results in lower prices received.

An analysis of production and demand for commodities grown in Massachusetts points to a number of fruits and vegetables wherein total production in the State is significantly below the volumes consumed (7), and therefore possess greater marketing potential (in terms of prices received by growers) than those commodities which have surpluses over consumption. Cauliflower and broccoli were mentioned by a number of informed individuals as showing the greatest local market potential (see footnote 31/). Lettuce, onions, tomatoes and small berries also show potential. Most growers, prior to shifting to new crops, must have some expectation that their investments will generate some minimal net return. Thus, improvements in peak season marketing techniques are needed to increase prices received. Another solution is to either extend the marketing season (increasing shelf life of produce or providing modern storage facilities) or extend the growing season through utilizing greenhouse production, and/or hydroponics. Such changes would result in enabling the grower to spread his delivery of produce over a greater period of time and therefore receive higher prices than received during peak-season, market-saturated periods.

The Massachusetts Department of Food and Agriculture (MDFA) has dedicated a vast amount of resources to expanding marketing outlets for farmers in order to establish a favorable "climate" to expand production and consumption of in-State grown products. Their efforts have concentrated upon the establishment of farm markets and farmer-operated roadside stands, both of which result in direct sales from farmer to consumer. The MDFA efforts have been successful. Two other forms of marketing organizations also show promise. The first entails marketing cooperatives wherein a number of growers band together and pool their produce (e.g., the Pioneer Valley Growers Association in Western Massachusetts). While such an arrangement has a number of risk factors, three key advantages exist: (1) By pooling produce, the cooperative can sell in larger volumes and thereby take advantage of scale economies; (2), the cooperative can, in many cases, allocate quotas to growers to minimize oversupply and thereby maintain or enhance prices (such as those arrangements that exist in the Ocean Spray Cranberry cooperative); (3) a large proportion of the value added to produce between delivery to the cooperative and delivery to the consumer would be retained by the cooperative members (participating farmers) in direct proportion to the participation rate of the members. The major disadvantage in forming a successful cooperative is the fact that participation is voluntary, and if retail prices increase over and above the price the cooperative is paying its members, some members may decide to take advantage of the higher retail price and direct market. Obviously, if too many members reacted in this manner, the volume of produce marketed by the cooperative could fall such that scale economies would be mitigated.

A second possible solution to expanding fruit and vegetable production through enhancement of marketing outlets, would be to establish a wholesaling firm committed to dealing with in-State farmers. However, such a firm would have to be assured of minimum produce flows from local farmers that meet minimum quality standards before investing entrepreneurs would find such an endeavor feasible. And growers, before shifting to high-demand varieties and making necessary investments to meet quality standards, would have to be assured that such a firm would succeed in increasing market outlets. A possible solution to this "chicken and the egg" dilemma might involve low interest, guaranteed loans by State and/or local governments.

FUTURE RESEARCH

The MAVS was designed to determine in as much detail as possible the causes and reasons for the decline in the Massachusetts Agricultural Sector over time. Budget and time constraints precluded any follow-up research designed to analyze current and suggested policy and program alternatives. However, the results of the study logically suggest a number of areas where future research would be desirable. These include but are not limited to the following: 32/

1. What is the potential adaptability of Massachusetts human and farmland resources to grow more fruit, vegetables, and other high valued food crops?
2. What are the opportunities for new wholesale and retail marketing arrangements?
3. Where is the location of the presently not-cultivated prime agricultural land, and what is the potential for conversion to agricultural uses?
4. To what extent are higher production costs offset by market proximity?
5. Can a map be developed identifying high, medium and low agricultural viability areas?
6. What are the long term NET public costs of the APR program?
7. What are the NET private costs of precluding future non-agricultural development upon prime or other agriculturally productive land?
8. What are the economic impacts of improving water quality regulations in areas of intensive agriculture?

32/ Many of these future research topics were developed by William King, Massachusetts Department of Food and Agriculture.

REFERENCES

- (1) Bahn, Henry M. and Robert L. Christensen. "Regional Self-Sufficiency in Food Production - The New England States," Journal of the Northeastern Agricultural Economics Council, Vol. VIII, No. 1, April 1979.
- (2) Barnett, H. J. and C. Morse. Scarcity and Growth: The Economics of Natural Resource Availability, Johns Hopkins University Press, Baltimore, Maryland 1963.
- (3) Berry, David. Idling of Farmland in the Philadelphia Region, 1930-1970, Regional Science Research Institute Discussion Paper Series: No. 88, Amherst, MA, March 1976.
- (4) _____, Ernest Leonardo, and Kenneth Bieri. The Farmer's Response to Urbanization: A Study of the Middle Atlantic States, RSRI Discussion Paper Series: No. 92, Amherst, MA, December 1976.
- (5) Black, John Donald. The Rural Economy of New England - A Regional Study, Harvard University Press, Cambridge, MA, 1950.
- (6) Braiterman, Marta, Sarah Fernandez, Jessie Pflager, et al. "The Agricultural Land Use Base of Massachusetts," Massachusetts Agricultural Experiment Station, Bulletin No. 639, Amherst, MA, May 1976.
- (7) Chickering, Ann Marie. Toward Greater Self-Reliance: An Assessment of Massachusetts' Food Production Potential, Cooperative Extension Service, University of Massachusetts, Amherst, August 1979.
- (8) Coffman, George W. Structure and Adjustments of the U.S. Farming Sector: A Data Base by Regions, U.S. Department of Agriculture, Economics and Statistics Service, October 1980.
- (9) Conklin, Howard and Richard Dymsha. Maintaining Viable Agriculture in Areas of Urban Expansion, New York State Office of Planning Services, Albany, 1972.
- (10) Conservation Foundation. The Future of America Agriculture as a Strategic Resource, edited by Sandra S. Batie and Robert G. Healy, Washington, DC, 1980.
- (11) Coughlin, Robert E., and others. Saving the Garden: The Preservation of Farmland and Other Environmentally Valuable Land, Regional Science Research Institute, A Report to NSF (RANN), Washington, DC, 1977.
- (12) _____, John C. Keene, J. Dixon Esseks, William Toner, and Lisa Rosenberger. The Protection of Farmland: A Reference Guidebook for State and Local Governments, National Agricultural Lands Study, U.S. Government Printing Office, 1981.

- (13) Dhillon, Pritam S. and Donn A. Derr. "Critical Mass of Agriculture and the Maintenance of Productive Open Space," Journal of the Northeastern Agricultural Economics Council, Vol. III, No. 1, May 1974.
- (14) Foster, John H. and William MacConnell. "Agricultural Land Use Change in Massachusetts, 1951-1971," Massachusetts Agricultural Experiment Station, Research Bulletin No. 640, Amherst, MA, January 1977.
- (15) Fronk, David R. "Farm Size and Regional Distribution of the Benefit Under Federal Milk Market Regulations," Federal Trade Commission, May 1978.
- (16) Gardner, B. Delworth. "The Economics of Agricultural Land Preservation," American Journal of Agricultural Economics, Vol. 59, No. 5, December, 1977.
- (17) Hart, John Fraser. "Urban Encroachment on Rural Areas," Geographical Review, Vol. 66, 1976.
- (18) Hopkins, Richard D., Robert L. Christensen, E. T. Bardwell, and Richard D. Andrews. An Analysis of the Optimum Number, Size, and Location of Feed Mixing Plants in New England, New Hampshire Agricultural Experiment Station, Durham, NH, August 1971.
- (19) Isard, Walter. Location and Space Economy, The M.I.T. press, Cambridge, MA, 1956.
- (20) Lewis, James A. Landownership in the United States, 1978, USDA, Economics and Statistics Service, Agriculture Information Bulletin No. 435, April 1980.
- (21) MacConnell, William. Remote Sensing 20 Years of Change in Massachusetts, 1951-1971, Cooperative Extension Service, University of Massachusetts, Amherst, published by county between 1973 and 1975.
- (22) Malthus, Thomas. An Essay on the Principle of Population, first published 1798 and 1830; edited by Anthony Flew, Pelican Books, Baltimore, MD, 1970.
- (23) Massachusetts Cooperative Extension Service. Survival of Agriculture in an Urbanizing Environment, University of Massachusetts, Amherst, MA, March 1977.
- (24) Massachusetts Department of Food and Agriculture, "A Policy for Food and Agriculture in Massachusetts." Boston, 1976.
- (25) _____. "Farmland Preservation in Massachusetts," Report of Progress, March 1981.
- (26) National Agricultural Lands Study. Final Report, U.S. Government Printing Office, January 1981.
- (27) National Agricultural Lands Study. "Massachusetts Fact Sheet," January 1980.

- (28) National Agricultural Lands Study. Soil Degradation: Effects on Agricultural Productivity, Interim Report No. 4, prepared by the National Association of Conservation Districts, November 1980.
- (29) New England Crop and Livestock Reporting Service. Massachusetts Agricultural Statistics, Concord, NH, published annually.
- (30) Paul, Allen B., Robert W. Bohall, and Gerald E. Plato. Farmers' Access to Markets, USDA National Economics Division, September 1980.
- (31) Perloff, Harvey S., Edgar S. Dunn, Jr., Eric E. Lampard, and Richard F. Muth. Regional, Resources, and Economic Growth, University of Nebraska Press, Lincoln, 1967 (2nd printing).
- (32) Platt, Rutherford H., Sarah Fernandez, and Lynn Reynolds. The Fertile Crescent of Massachusetts: Farmland Policy Issues of the Connecticut River Valley, Connecticut River Watershed Council, Inc., December 1975.
- (33) Reimund, Donn A., J. Rod Martin, and Charles V. Moore. Structural Change in Agriculture - The Experience for Broilers, Feed Cattle, and Processing Vegetables, USDA, Economics and Statistics Service, Technical Bulletin No. 1648, Washington, DC, April 1981.
- (34) Resources for the Future. Contemporary Issues in Natural Resource Economics, edited by Emery N. Castle, Reprint 152, Washington, DC, 1978.
- (35) Schertz, Lyle P., et. al. Another Revolution in U.S. Farming?, U.S. Department of Agriculture, Agricultural Economic Report No. 441, December 1979.
- (36) Seaver, Stanley K. and William J. Hanekamp. Recent Developments in Feed Transportation to New England, Storrs Agricultural Experiment Station, University of Connecticut, Storrs, Research Report No. 48, December, 1977.
- (37) Simon, Julian L. "Resources, Population, Environment: An Oversupply of False Bad News," Science, Vol. 208, June 27, 1980.
- (38) Smith, Frederick E. "The Environment", The Farm and the City: Rivals or Allies?, edited by Archibald M. Woodruff, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1980.
- (39) Stinson, Robert L., P. Geoffrey Allen, Robert L. Christensen. Current and Projected Output of the Massachusetts Livestock Industry and Its Marketing Structure, Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, Research Bulletin Number 659, December 1978.
- (40) _____. The Economic Feasibility of Constructing Additional Livestock Slaughter Facilities in Massachusetts, Massachusetts Agricultural Experiment Station, Amherst, Research Bulletin Number 660, December 1978.
- (41) Thompson, Edward Jr., "Farming in the Shadow of Suburbia: Case Studies in Agricultural Land Use Conflict," National Association of Counties Research Foundation, Washington, DC, December 1980.

- (42) Tremblay, Raymond H. 1978 ELFAC Dairy Farm Business Analysis, Cooperative Extension Services of the Northeastern States, University of Vermont, Burlington, Report NE-232, June 1979.
- (43) Tweeten, Luther. Foundations of Farm Policy, University of Nebraska Press, Lincoln, 1970.
- (44) U.S Department of Agriculture: Agricultural Statistics, Government Printing Office, published annually.
- (45) _____. Perspectives on Prime Lands, Background papers for a Seminar on the Retention of Prime Lands, July 1975.
- (46) USDA Crop Reporting Board. Agricultural Prices - Annual Summary, published annually.
- (47) _____. Farm Labor, published quarterly.
- (48) USDA, Economic Research Service. The Chicken Broiler Industry: Structure, Practices, and Costs, Marketing Research Report No. 930, May 1971.
- (49) USDA, Economics, Statistics, and Cooperatives Service. Changes in Farm Production and Efficiency, 1978, Statistical Bulletin No. 628, January 1980.
- (50) _____. "Will Midsize Farms Fade as Small and Big Farms Multiply?" FARMLINE, Vol. III, No. 3, Apr 82. p. 4.
- (51) _____. Measurement of U.S. Agricultural Productivity: A Review of Current Statistics and Proposals for Change, Technical Bulletin No. 1614, February 1980.
- (52) _____. Structure Issues of American Agriculture, Agricultural Economic Report 438, November 1979.
- (53) USDA Rural Development Service. Farm Population Estimates, 1910-70, Statistical Bulletin No. 523, July 1973.
- (54) U.S. Department of Commerce, Bureau of the Census. Census of Agriculture, published every ten years starting in 1840 and every five years starting in 1920.
- (55) U.S. Department of Commerce. 1977 Census of Manufactures, Geographic Area Series, 1980.
- (56) _____. 1977 Census of Wholesale Trade, Geographic Area Series 1980.
- (57) _____. County Business Patterns, 1959, 1964, 1974, 1978.

- (58) U.S. Department of Commerce. Statistical Abstract of the United States, 1978, 99th Annual Edition, 1980.
- (59) Van Arsdall, Roy N. Structural Characteristics of the U.S. Hog Production Industry, USDA, Economics, Statistics and Cooperatives Service, Agricultural Economic Report No. 415, December 1978.
- (60) Vosloh, Carl J., Jr. Feed Manufacturing Costs and Capital Requirements, USDA, Economic Research Service, Agricultural Economic Report No. 335, May 1976.
- (61) _____. Structure of Feed Manufacturing Industry, 1975 - A Statistical Summery, USDA, Economics, Statistics, and Cooperatives Service, Statistical Bulletin No. 596, February 1978.
- (62) Wilson, Leonard U. State Agricultural Land Issues, The Council of State Governments, Lexington, KY, August 1979.
- (63) Zimmerman, Erich W. World Resources and Industries, Revised Edition, Harper & Brothers, New York, 1951.

Appendix I to the Massachusetts Agricultural Viability Study

An Evaluation Framework for Water Erosion in Massachusetts

A high-ranking official of the U.S. Department of Agriculture noted that sediment is America's number one degrader of water quality, by volume. It is a multiple threat because it often carries with it pesticides, fertilizers, and other chemicals. Much of the total sediment load in streams and lakes comes from agricultural land. Just how much, and how this affects water quality are questions still being explored. 1/

Neil Sampson, executive vice-president of the National Association of Conservation Districts, warns that "Soil erosion, farmland conversion, water and soil quality problems are reaching epidemic proportions." 2/

For the most part the Water Quality Plans prepared in Massachusetts under Section 208 of the Federal Water Pollution Control Act of 1972 (PL 92-500) did not adequately address agricultural pollution sources. This shortcoming was realized during the development of the work outline for the Massachusetts Agricultural Viability Study (MAVS). Although the funding level provided for the MAVS did not permit a thorough analysis of the issue of agricultural water quality pollution, it was decided that the topic was too important to be excluded from the study.

In order to assess the impacts of various alternative solutions to agriculturally induced water quality problems, a linear programming (LP) model was developed. The primary advantage of such a model is that the physical and economic relationships can be jointly investigated, and such a model provides a means to efficiently test the physical and economic effects that result from alternative solutions (rotations, conservation practices, erosion reduction targets, and production impacts). While the model employed is generalized for the State of Massachusetts, it is readily adaptable for use in specific watersheds. In addition, an LP assists in determining the most efficient (least costly) means to reduce erosion to acceptable levels.

1/ D. G. Unger, "Improving Water Quality in Agriculture and Silviculture," in BMPs for Agriculture and Silviculture, Locke, Haite, et al., editors, Ann Arbor, Michigan, University of Michigan Press, 1979.

2/ Neil Sampson, "Poor Policy and Erosion Bankrupt Farming," New Farm, March/April 1982, p. 64.

LINEAR PROGRAMMING EXPLAINED

An LP model is an analytical tool which incorporates an objective function (defined as maximizing profits or minimizing costs). ^{3/} An LP model is highly useful in that a problem can be evaluated with the entire "system" that encompasses the problem incorporated in the evaluation. The LP does this by recognizing real world constraints that surround a solution to any defined problem. In this portion of the MAVS, the LP model incorporates a cost minimizing objective in meeting acceptable erosion levels. For example, because of ever increasing feed costs, dairy farmers in Massachusetts have been increasing the acreage used to grow corn for silage. As that acreage continues to increase, the potential for increased erosion and subsequent sediment induced water quality problems increases. Thus, if the objective function is set at some acceptable level of costs for an acceptable level of erosion (x tons per acre) given constraints of land, labor, and capital, the LP model will generate an optimal solution that minimizes costs of attaining a land use mix (cropping mix that results in acceptable erosion levels).

An LP is an analytical procedure for determining optimal levels of resource allocation. Such a procedure considers all combinations of activities specified in a mathematical model and constrains combinations of activities to use no more than the available amount of resources. An optimal solution is selected from these combinations, which mathematically, is equivalent to optimizing a linear objective function subject to a set of constraint equations. These constraints represent the amount of inputs required for each activity and the amount of scarce resources available as inputs. The objective function for the erosion model is:

$$\text{Min } X_o = \underset{1}{236.22X} + \underset{2}{162.59X} + \underset{3}{181.00X} \dots\dots\dots \underset{42}{176.40X}$$

The X's represent different agronomic practices and rotations used to grow corn silage and hay. The coefficients are the per acre production cost for each of the activities in the model. The constraints, as applied to this analysis, involve production constraints for each Soil Productivity Group being analyzed. Conservation practices (stripcropping; no tillage, corn, hay, rotation; and no tillage, continuous corn rotation) are also incorporated.

PROBLEM DEFINITION

The 1978 Census of Agriculture for Massachusetts reported cropland acreage amounting to 311,033, of which 69 percent (213,699 acres) were harvested. While a large variety of crops are grown in the State, two cropland uses account for over 83 percent of the total harvested cropland acres (hay: 133,117 acres, and corn, mostly silage: 44,267 acres). Production from these two crops amounts to well over a million tons of forage. Because of the high percentage of hay acreage in the State,

^{3/} For an excellent description and application of LP models, see Bender, et al., Systems Analysis for the Food Industry. The AVI Publishing Co., East Port, CT, 1976.

Massachusetts does not experience the severe erosion problems that are found in many farming regions in the nation. However, this does not mean that there are no significant erosion and related water quality problems in the State. Quite the contrary; areas in the Connecticut River Valley and parts of Worcester and Plymouth Counties are intensively farmed with a high proportion of row crop acreage. In addition, as costs of livestock feed continue to increase, many farmers have, and will continue to increase corn silage acres by growing corn on present hay land. As this trend continues, the potential erosion and subsequent water quality problems will increase.

DATA USED

Data Base: The data base used in this analysis contains three sets of data: (1) soil productivity groups (SPGs); (2) estimates of gross soil erosion for each farming activity on each soil group; and (3) crop budgets for each of the crops and the farming activities used in the production thereof. The actual procedures that were employed in the development of the soil productivity groups are contained in the Annex to this Appendix.

Soil Productivity Groups (SPGs): Two key criteria were used to determine which soils would be selected. First, that the soil be used for growing row crops, and secondly, that the soil has a physical potential for significant erosion. Utilizing the 1977 Massachusetts Natural Resources Inventory, which was conducted by SCS, eight land capability subclasses are used for row crops (1, 2e, 2w, 3e, 3s, 3w, and 4s). A screening of these soils resulted in the selection of five land capability subclasses that possess erosion potential (2e, 2s, 3e, 3s, and 4s). This information, together with soil survey information, permitted the development of six soil productivity groups (SPGs) that are used for row crops and that also have potential erosion problems (Table 1). The distribution of these mapped soils was used to estimate unmapped soils. Six SPGs were created and represent nearly 25,000 acres or 12 percent of the State's harvested cropland.

Table 1--Soil Productivity Groups

Group	No. of Soil series	Row Crop (acres)	Avg. Yield silage T/A	Avg. Yield hay	Avg. Slope	Annual Erosion for continuous row crop (T/A)
A	12	1,416	24	4.5	3-8%	17.0
B	20	10,416	24	4.5	3-8%	9.5
C	6	758	15	3.0	3-8%	13.2
D	44	8,406	19	3.5	8-15%	32.5
E	15	917	22	4.0	8-15%	58.1
F	6	2,759	16	3.0	8-15%	23.0
	103	24,672				

Gross Soil Erosion Estimates: A soil loss estimate for each soil group and farming activity was calculated using the Universal Soil Loss Equation (USLE). The activities represent various crop rotations and conservation practices. The equation is a mathematical description of the major factors known to influence rainfall erosion (Equation 1).

$$A = RKLSCP \text{ (Equation 1)}$$

where:

A is the computed water erosion per acre of area (tons per acre). It does not include large quantities of soil material that may be lost by rill and gully erosion.

R is a rainfall and runoff factor.

K is the soil erodibility factor and reflects the fact that different types of soil erode at different rates when other factors affecting erosion are constant. The physical characteristics of the soil affect its susceptibility to rainfall erosion; e.g., sandy soils are less erodible than silty soils.

L is the slope length factor and is defined as the ratio of erosion from the field slope length to that from a 72.6 foot length on the same soil type and gradient.

S is the slope gradient factor and is the ratio of erosion from the field gradient to that from a 9 percent slope (tables are available which combine L and S into an LS factor for specific soils).

C is the cropping management factor and is the ratio of soil loss from a field with specified cropping management to that from a fallow condition which the factor K (above) is estimated.

P is the erosion control practice factor, the ratio of erosion with contouring stripcropping, or terracing to that with straight row farming (up and down slopes).

Once these erosion rates were determined they were used as an erosion constraint. A constraint is essentially a requirement that must be met in solving the objective function. For erosion the constraint can be set at some predetermined level. The solution is bounded by this constraint. That is, activities which would result in the constraint being exceeded are not selected by the LP model.

Crop Budgets: There are seven different activities associated with each SPG model for a total of forty-two activities. Crop budgets (on a per acre basis) were prepared to represent the inputs used to produce a crop given a particular agronomic practice. Variable pre-harvest and harvest costs were used in developing the budgets which, for multiple crop rotations, were weighted over the rotation period (four years).

After the data base was prepared, a tableau was created (Table 2). This tableau represents the linear programming model for evaluating soil erosion in Massachusetts. This model provides a systematic basis for estimating overall costs for alternative erosion control levels in terms of reductions in crop production, changes in the crop production practices, and total production costs.

There are twelve constraints in the model. The first two constraints are production constraints which tell us how much corn or hay will be produced. The coefficients in these constraints are the yields which we can expect for the crops given certain rotations and practices. Constraints 3 through 8 are acreage constraints for each soil productivity group. Constraints 9, 10, and 11 represent three conservation practices that are used in the model. These are stripcropping, no tillage for a corn hay rotation, and no tillage for continuous corn. These are set at greater than or equal to zero in order for the program to allocate some acres to these conservation practices. The final constraint is the soil erosion constraint. The coefficients here are the erosion in tons per acre per year which were calculated using the USLE. This constraint can be set at greater than or equal to zero in which case we can find the level of erosion which will have to be tolerated to optimize the objective function. Alternatively, this constraint can be set at some predetermined level. By doing this, the impact that erosion control has on the choice of activities in the model can be determined.

A cost minimization model was set up. The corn silage and hay constraints were manipulated until production was maximized. The production level was 269,500 tons of corn silage and 49,500 tons of hay. A total of 24,672 acres were included in the model. These acres were distributed among the six SPGs (Table 1). The conservation practice and soil loss constraints were set at greater than or equal to zero.

MODEL RUNS

The problem was solved using an LP computer program for linear programming called LPROG. The value of the objective function was \$4,398,000. This represents the cost to produce 269,500 tons of silage and 49,500 tons of hay while satisfying the constraints placed on the model. All acres for each group were allocated. The solution included various crop rotations ranging from all corn on SPG B to all hay on SPG D. All tillage was conventional. To minimize cost, the program seeks those activities which have the lowest costs. A slack or surplus value was generated for the soil loss constraint. This value is 113,900. This means that to optimize the objective function (vis. minimize production cost) 113,900 tons of soil loss would have to be accepted. This is an average of about 4.6 tons per acre. The "tolerable" erosion for the soils in the model is approximately 3 tons per acre.

A subsequent run was made setting the soil loss constraint at less than or equal to 73,258 tons. This is the aggregated soil loss at the tolerable level. Results are shown in Table 3. For this run, 18,237 acres of no tillage farming were selected. This represents about 74 percent of the total acreage. Given

the assumed crop mix, erosion control can be achieved by using conservation tillage practices. The economic impact, at least in terms of variable production cost, would be minor.

The production statistics for corn indicate a steady increase in acreage for recent years. Hay production appears to have varied much more on a year-to-year basis, but overall is declining in acreage. Rising feed costs may be prompting Massachusetts farms to rely more on silage production. While farm operators may realize a cost reduction and the State may become less dependent on imported feed grains, one impact which deserves consideration is the effect that increased silage production will have on erosion.

Increased silage production was introduced into the model. The target was raised from 269,500 tons to 402,000 tons, roughly a 50 percent increase. Most, if not all, of the acres required for this increase would have to come from hay acreage especially those soils included in the SPGs. A base run yielded the results presented in line 3 of table 3. Erosion increased significantly. An attempt was made to limit the soil loss to the tolerable constraint at this level of production, but a feasible solution could not be attained.

A final run, the results of which are given in lines 4 and 5, Table 3, found the maximum corn silage production possible while applying a tolerable soil loss constraint. The first attempt (line 4) sought to produce only corn silage and no hay. Only about 70 percent of the acreage was used and 371,425 tons produced representing an average yield per acre of 21.6 tons per acre. The solution generated all but 917 acres of no till. The second run (line 5) introduced hay. Interestingly, corn silage had to be decreased by less than 10 percent when 28,945 tons of hay were produced. All but 214 acres were used.

CONCLUSIONS

The linear programming model described here is an effective tool in determining the costs of reducing erosion in terms of both production foregone and increased costs. Using generalized data, we found that because of the great amount of hay acreage within the State, the erosion across the State is not severe and could be corrected with minor economic impacts. However, as row crops are introduced upon hayland, erosion control practices are needed which increases production costs. If not applied, the potential for environmental degradation increases. There is, in fact, an upper limit on the amount of row crop production that is economically feasible and environmentally sound given a tolerable soil loss constraint.

Table 3--Linear Programming Model Results

Run	Cost (thousands)	Erosion Gross (Tons)	Acres		Production (1000 tons)		Practices		Strip Crop	Erosion T/Acre/Yr.
			Cropland	Hay	Corn	Till	Corn	No Till		
1. Base	4,398	113,900	24,672	49.5	269.5	24,672	0	0	0	4.6
2. Tolerable soil loss	4,414	73,258	24,672	49.5	269.5	6,435	18,237	0	0	3
3. Increased silage pro- duction w/o soil loss constraint	4,818	312,800	24,672	24.5	402.0	24,672	0	0	0	12.7
4. Max. silage production with soil loss constraint	3,657	73,258	17,175	0	371.4	917	16,258	0	0	3
5. Max. silage hay mix with soil loss constraint	4,718	73,258	24,458	28.49	368.0	7,652	15,349	1,457	0	3

Annex to Appendix 1

SOIL PRODUCTIVITY GROUP FORMULATION AND EROSION ESTIMATION PROCEDURE

This section describes the procedure used to group the soils of Massachusetts that are suitable for agriculture and subject to erosion, and whose parameters would be generally descriptive of the soil series contained within each group. The parameters used are the factors of the USLE.

Each soil series that occurs in the State was categorized by the land capability classes and subclasses. Each series with its different class/subclass was represented by a single index card. Cards were made only for classes I-IV land, because any class greater than IV would not be used for row crops. A stony, rocky, or gravelly series was included on the same card as the regular series. However, very or extremely stony, rocky, gravelly, and boulderly soils were not included on the cards. For example, there would be one card for Hadley IIe, another for Hadley IIw, and so on. The mapped acres from each published soil survey report and town report, and from each unpublished report were recorded by town, partial county, county, or Federal land, onto the cards. The acres on each card were then totaled in order to complete the number of acres for each series on the class/subclass level.

In order to analyze the erosion problem on a Statewide basis, it was necessary to collect data on those acres the soils of which had not been mapped. In order to do this, the 1977 Natural Resources Inventory (NRI) Study which gives acres of land at the class/subclass level for the State was utilized. In order to use the NRI data to obtain a figure for acreage of each series at the class and subclass level, some manipulation of the data was necessary, and limitations of the data had to be considered. One of the limitations of the NRI data was described by Mr. Hance of the Washington SCS office. Based on 1) distribution of soil series, and 2) frequency of soil series within the State, the statistical reliability of the acreages given is about 80 percent at the class level (i.e., accuracy between actual mapped soils acreages and NRI soils acreages) and about 50 percent reliable at the subclass level.

Another limitation of the study was that it did not include urban and Federal land. It accounted for 3,576,000 acres out of the 5,000,000 in the State. In order to project NRI subclass totals to include urban and Federal land, the totals were expanded on a percentage basis (i.e., the NRI subclass totals were divided by 3,576,000 and then multiplied by 5,000,000 - which resulted in the expanded subclass totals).

The total acres on each soils card was then expanded on a percentage basis, up to the NRI/subclass total. The result was a number of series-specific subclass totals. Total acres of a particular subclass; e.g., IIe were obtained by adding up soil series card totals that were of the same subclass. The NRI subclass totals were then divided by the mapped subclass totals and the result was used as an adjustment factor. Each soil series in that subclass was multiplied by the adjustment factor for that subclass and the result was the expanded soil series total for the subclass level in the State.

The cards were then organized into similar productivity groups. Also, a new set of cards was developed which included the following information: soil series name, class, subclass, slope range, K factor, T factor, crop yield, potential, number of total acres in the State and the number of row crops in the State. The first 7 items were all obtained from "Soils 5" sheets, except where, in some cases, crop yields were not reported on the sheets. In this case, the yields from "Planning Guide Sheets, Agronomic Interpretations, June, 1980," were used. The 8th item was the expanded totals which were described above, and the 9th item, row crops, was obtained by the manipulation of NRI data. NRI gives a figure for row crops in Massachusetts for the subclass level. This figure divided by the total number of acres in the State of that subclass gives a fraction that is used as a constant. The constant for each specific subclass is then multiplied by any soil series card that is in the same subclass. Thus, on a percentage basis, the row crop series specific-total is obtained.

All of these criteria were used because they are indicators of the productivity of the soil type. The row crop acreage is useful because erosion occurs in Massachusetts primarily on soils in which row crops are grown. Because erosion is a significant problem mostly in "e" subclass soils or "s" subclass soils with steep slopes, only the "e" and "IVs" row crop totals were taken from the NRI Study. Erosion is not a major problem on Class I soils so the row crop totals for I were not used, and according to NRI data there are no row crops grown on IVe soils. Therefore, the row crop calculations were performed on IIe, IIIe, and IVs soils.

The cards were then grouped according to similarities in the criteria listed above, and only the cards that were in the subclass groups of IIe, IIIe, and IVs were included in the groupings. Six soil productivity groups were formed, labeled A-F.

Each of these SPGs were formed with the idea that an individual number for each of the factors in the USLE could be obtained and, at the same time, be representative of all the soils in a particular group.

In order to obtain a length of slope (LS) factor for each group that would be somewhat representative of all the soils within the group, and since the data for soils are not site-specific, Henry Ritzer (Resource Conservationist) and Gene Grice (State Soil Scientist) were consulted as to the typical slope length of particular slope percents in Massachusetts. According to them, the following slope lengths are representative of these slope ranges:

<u>Slope Range</u>	<u>Average Slope</u>	<u>Average Slope Length</u>
0-3%	1.5%	300 feet
0-8%	4.0%	250 feet
3-8%	5.5%	200 feet
8-15%	11.5%	150 feet
15-25%	20.0%	100 feet

The weighted averages for percent slope and slope length was calculated based on the percentage of acres of a soil type of a particular slope that were in the total acreage of the group. With these two values, percent slope and slope length, an approximate LS for each group was determined.

Once the values for all of the factors of the Uniform Soil Loss Equation were determined, soil loss estimates for each crop rotation were estimated and entered into the model on the line labeled "erosion."

Bibliography

Bender, et al., Systems Analysis for the Food Industry, East Port, CT, AVI Publishing Co., 1976.

Christensen, Robert and Ashraf, Muhammad, "Economic Costs of Water Quality Protection on Dairy Farms," Water Resources Bulletin, Vol. 10, No. 2, April 1974.

Kasal, James, "Trade-offs between Farm Income and Selected Environment Indicators: A Case Study of Soil Loss, Fertilizer, and Land Use Constraints," U.S.D.A. Economic Research Service, Tech. Bulletin 1550.

Loerr, et al., Best Management Practices, Ann Arbor: Ann Arbor Science Publishers, 1979.

Ogg, Clayton; Christensen, Lee; and Heimlich, Ralph, "Economics of Water Quality - Agriculture - Agriculture Review," U.S.D.A., E.S.C.S. Report #58.

Ogg, Clayton; Heimlich, Ralph; and Hostetler, John, "A Modeling Approach to Making Watershed Conservation Plans," unpublished manuscript.

Osteenal, Craig and Seitz, Wesley, "Regional Economic Impacts of Policies to Control Erosion and Sedimentation in Illinois and Other Corn Belt States," AJAE, Vol. 60, No. 3, August 1978.

Robillard, Paul; Water, Michael; Hexem, Roger, "Evaluation of Agricultural Sediment Control Practices Related to Water Quality Planning," Journal of Northeast Agricultural Economic Council, April 1980.

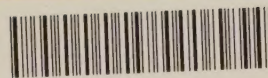
Sampson, Weil, "Poor Policy and Erosion Bankrupt Farming," New Farm, Rodale Press, March/April 1982.

Sharp, Basil and Bromly, Daniel, "Agricultural Pollution: The Economics of Coordination," AJAE, Volume 61, No. 4, November 1979.

Taha, Handy A., Operations Research An Introduction, New York, MacMillan Co., 1976.

U.S. Environmental Protection Agency, Guidelines for Evaluation of Agricultural Non-point Source Water Quality Projects.

White, G. B. and Partenheimer, E. J., "The Economic Implications of Erosion and Sedimentation Control Plan for Selected Pennsylvania Dairy Farms,"



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